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The Commander's Independent Thermal Viewer (CITV) is among the most promising add-ons for the M1A1. A scheme to test whether addition of the CITV alone to the M1A1, without adding any of the other M1A2 improvements, is conducted to measure lethality, survivability, and detection performance.

The JANUS(A) combat model is used to collect data. Battalion and squadron level scenarios were conducted for both Central Europe and Southwest Asia during both day and night conditions. Measures of performance are analyzed in each of the three areas to determine the influence of the CITV on M1A1 performance.

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An Evaluation of Varying Distribution Policies For The Commander's Independent Thermal Viewer On U.S. Army Main Battle Tanks

by

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of the requirements for the degree of

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ABSTRACT

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I. INTRODUCTION

A. GENERAL

This thesis investigates whether addition of the Commander's Independent Thermal Viewer (CITV) to the US Army's M1A1 Main Battle Tank (MBT) increases the weapons system's lethality and survivability. The following chapters evaluate the benefit of retrofitting a specified percentage of the existing fleet of M1A1 tanks with certain technologies developed for the M1A2 tank.

B. BACKGROUND

1. M1A2 Program History

The M1A2 program was approved on 19 February 1985 as a fightability enhancement of the M1A1 tank. In actuality, the M1A2 tank is a near-total redesign which shares certain core component characteristics with the existing M1A1 tank. The fightability enhancements approved in February 1985 included Survivability Enhancements (i.e. improved heavier armor), an Improved Commander's Weapon Station, a Carbon Dioxide Laser Rangefinder, a Position Navigation System, the integration of the Driver's Thermal Viewer, the Radio Interface Unit, and the Commander's Independent Thermal Viewer (CITV). During the course of the last seven years the program has been revised many times.

In March 1990 a special review resulted in the decision to procure only 62 M1A2 tanks. These tanks are to be built with the Improved Commander's Weapon

Station, Position Navigation System, specified Core Architecture (i.e. digital electronics components and databus), and the Commander's Independent Thermal Viewer. The Secretary of Defense issued a program budget decision in December 1989 terminating M1A2 production after the limited 62 tank production run. Although future Foreign Military Sales may warrant continued production, there is no current U.S. plan to purchase more than the 62 tanks specified by the Secretary.

2. The Commander's Independent Thermal Viewer (CITV)

The current generation M1A1 tank is not equipped with a CITV. The tank commander has a sight which is an extension from the gunner's primary sight (GPS) and is not capable of any independent movement. The tank commander may search for targets in a number of modes: he may be fully exposed (head and shoulders outside of tank hatch) using unaided vision, fully exposed and using binoculars or night vision goggles, in a closed hatch mode using the unaided vision periscopes, or he may be using the tank commander's extension of the GPS in either a daylight or thermal mode.

According to the M1A1E2 Tank Program System Specification, the CITV shall:

> provide the commander with the independent capability to perform surveillance and target acquisition with performance equivalent to the Gunner's Primary Sight (GPS) Thermal Imaging System (TIS). In addition, it shall provide the commander with the ability to handoff targets to the gunner and also provide a backup means to fire the main armament system. The CITV shall be stabilized to provide operation while the tank is stationary and on-the-move. [Ref. 1: vol IV, p. 2]

The CITV should provide the weapon system with greater acquisition and detection capability thereby increasing the tank's lethality (kills more enemy) and survivability (kills enemy faster than the enemy can engage the tank).

The CITV is an independently stabilized thermal sight. This means that the view will remain fixed in both azimuth and elevation as the tank moves. This allows the tank commander to clearly view on-the-move. The stabilization is independent of the gunner's sight system, thereby allowing multiple fields of view from the weapon system. The thermal capability indicates that the sight is an infrared type, developing an electronic image by detecting varying levels of emitted heat. Such a design has been used for many years in both the M60A3 and M1 series tanks as well as attack helicopters and other weapons systems. The thermal sight provides the user with enhanced visibility and detection capabilities in times of darkness or decreased visibility (smoke and battlefield obscurants).

The CITV enhancement is much more than a vision device, in fact, it is an entire system. The CITV enhancement package would provide the functions of:

- Independent stabilized thermal sight
- Continuous 360° surveillance
- Detection, recognition, and identification equal to Gunner's Primary Sight thermal system
- Backup firing and sighting system
- Enables hunter-killer (target designate) operations

- Auto scan of a selected sector
- Search and gun line-of-sight modes

Not only does the CITV afford the tank commander a better view of the battlefield, it also allows him to designate targets not already identified by the gunner, engage those targets himself if necessary, and relieve the gunner of sectors of scanning responsibility.

The hunter-killer capability allows the gunner and tank commander to independently search exclusive or overlapping sectors of responsibility. In a typical scenario, the tank commander can issue a command for the gunner to engage a detected target. While the gunner is in the process of engaging the known target, the tank commander can continue to search for additional targets without interfering with the gunner's ability to engage and destroy the known target. If the tank commander identifies a new target, he may "designate" that target to the gunner upon the gunner's completion of action against the first known target. The tank commander depresses a switch on his fire control handle and the gunner's sight and the gun align with the tank commander's CITV view axis. The gunner may now immediately engage the new target without excessive search delays. This cycle of engage-search/ designate-handoff-engage may continue until battle termination. Alternately, the tank commander has backup engagement capabilities. If, for instance, the gunner is unable to acquire the designated target, the tank commander may engage the target with the main armament using the CITV sighting system.

Also, if the tank commander determines that the target he has identified takes immediate priority over the target being engaged by the gunner he may supersede the gunner's known target and immediately engage the new target. It should be intuitively obvious that the integrated CITV system has the potential of significantly increasing the number of targets detected, identified, and engaged/destroyed. This capability seems especially appealing when the tank is in a defensive posture. In a defensive scenario the tank is usually stationary, in defilade or a prepared position, and generally enjoys the advantage of being able to see the enemy much sooner than the enemy is able to detect the tank's location.

C. PROBLEM STATEMENT

The United States Army is committed to supplying the soldier with the best possible equipment. At the same time, the Department of Defense is coming to grips with the fiscal realities of expensive weapons systems acquisition. In an effort to determine an appropriate acquisition strategy, the US Army Training and Doctrine Command (TRADOC) and the US Army Armor Center (USAARMC) have posed the following questions:

1. What percentage of the current M1A1 fleet should be equipped with selected upgrades similar to the enhancements proposed for the M1A2 tank?

2. If certain enhancements are selected, what are the tactical fielding implications?

This thesis will focus on the former question; what the Armor Center has called the issue of "Differential Loading". Using the JANUS(A) combat model, this thesis will examine what measure of effectiveness increases, if any, occur when adding the CITV capability to a fixed force incrementally. The latter question is one of doctrine and is beyond the scope of this investigation. Naturally, any full-scale attempt to optimize the force would necessarily involve an investigation of cost factors. No attempt is made to include cost as a measure or to quantify its impact on procurement issues. This thesis will solely address the impacts on battlefield performance.

The following chapters detail the methods used to approach the problem. Chapter II discusses the JANUS(A) combat model and explains the modifications necessary to use the simulation for this thesis. Chapter III covers the measures of performance and measures of effectiveness used and lays the foundations for Chapter IV, the analysis of the data produced using the simulation. Finally, Chapter V presents conclusions and highlights areas of possible further study.

II. MODELING THE CITV

The JANUS(A) combat model is used to create scenarios and generate data necessary to analyze the performance of the CITV enhancements. It is necessary to modify the JANUS(A) source code to represent the multiple sensor capability of the CITV-equipped tanks (in fact, the use of the improved sensor algorithms better represents the acquisition of any crew-served weapon system in general.) A cursory overview of the JANUS(A) combat model is presented to motivate the modifications made to allow independent sensor application.

A. THE JANUS(A) COMBAT SIMULATION

JANUS(A) is a high-resolution, stochastic combat simulation developed and released by TRADOC Analysis Command, White Sands Missile Range (TRAC-WSMR). It is written in approximately 85,000 lines of FORTRAN-77 and configured to run on Digital Equipment mainframe or minicomputers running the VAX VMS operating system. JANUS(A) provides the user the ability to build very specific, realistic combined arms scenarios that are relatively easy to modify and manipulate. The user interface is via two methods: a standard VT220 display and keyboard combination or a graphics screen/mouse combination. Once a scenario is loaded and initialized, the user may interrupt the simulation, make modifications, or abort the run. There is moderate flexibility in the simulation, and it is easy to learn.

1. JANUS(A) Search and Detection/Acquisition

As this thesis is primarily an evaluation of additional detection hardware, it is necessary to examine how JANUS(A) models acquisition. The current JANUS(A) version uses an adaptation of the Night Vision Electro-Optical Laboratory (NVEOL) search and detection model. [Ref. 2:pp. 352-365] This widely-used model mathematically computes a probability of detection of a single target by a lone observer.

Modeling of detection and acquisition is essentially a two-phased process. JANUS(A) must model the physical system or stimulus presented by a target and the acquirer's response to the stimulus. The physical stimulus is limited by a detector's capabilities. A detector or sensor may be optical, such as unaided human sight or magnified sight, or thermal. In the case of optical sensors, the limiting physical characteristic is the number of "cycles" resolved by the observer on the target. The measure in cycles is the finest resolvable difference in contrasting adjacent lines distinguishable by the observer. A calculation of the resolvable cycles is dependent upon the contrast of the target as it appears to the observer's sensor, the number of cycles per milliradian that the sensor can resolve given the contrast level, and the target's presented dimension and range. In the case of thermal sensors, contrast is defined as the "absolute value of the average target to background temperature difference." As will be discussed later, this method of detection is important to the combat modeling methods presented in Chapter III.

The observer's response is dependent on a number of physical and technical parameters. Every 20 seconds of simulation time a list of at most 5 potential target units is composed. The following conditions must be satisfied:

1. the observer must have line-of-sight to the target
2. the observer must resolve a sufficient "cycle ratio" on the target unit, and
3. the target must be in the observer's sector of search (defined by the user).

If there are more than 5 targets satisfying the listed criteria, only the 5 with the most cycles are put on the potential detection list.

Under JANUS(A) version 2.0, a weapon system may have no more than 2 sensors, however, only one sensor is used at any given time. Based on user-defined parameters, the simulation alternates between primary and secondary sensors, using only one at any given time, until a detection occurs. Each 2 seconds of simulation time an observer queries the potential detection list and attempts to "acquire" the target. A random Uniform (0,1) draw is made for each potential target and compared to a calculated probability of detection for the given target. If the draw is less than or equal to the computed probability of detection, the target is acquired. The target will remain on the acquired list until the target is no longer within the observer's field of regard, line-of-sight is lost, or the target is destroyed. Additionally, JANUS(A) assumes that a detection is equivalent to positive identification (classification), and, once detected, the target is eligible for engagement (i.e. placed on a target list).

A weapon system may be in full or partial defilade when not moving, that is, either fully or partially hidden, or fully exposed. When not in defilade, a weapon system's search sector, which I will refer to as field of regard, is a circle centered at the weapon system, with a radius of "visibility" based on both physical and technical limitations. When in defilade, the field of regard is restricted to a wedge with locus at the weapon system and azimuth set by the user. Both the azimuth and angular width of the field of regard are set by the user. When moving, a weapon system has a full 360° field of regard.

There is a difference, however, between field of regard and field of view. The former may be thought of as an assigned area to search or scan while the latter is a limitation due to the hardware. Hardware-related specifications are set by the user and stored in a parameter data file.

2. JANUS(A) Limitations

As with any simulation, there are many limitations to the JANUS(A) combat model. The following areas are the limitations which significantly affect the evaluation of the CITV upgrade. JANUS(A) is used with no "man in the loop", assuring reproducibility, but negating many interactive capabilities. The first three limitations could be addressed by using a group of qualified experts to act as the man in the loop for each side, adding to the realism but reducing the reproducibility of the experiment. The last two limitations may be addressed with software modification to the model, but were beyond the scope of this thesis.

a. No synergistic information sharing

The JANUS(A) combat model is an aggregation of many individual weapon systems battles; each weapon system operates as though alone on the battlefield versus the enemy. As detections occur they are not shared with other members of the platoon or company, nor is the intelligence passed to higher echelons of command. Additionally, visual cues, such as adjacent tanks firing or being fired upon, are not simulated. If a target is acquired or engaged by one tank, the information on enemy location, type of enemy systems, speed, movement axes, and suspected intent is not shared with anyone. The implication here is that *if* the information *was* shared some type of effect on the force performance should be seen. If the CITV provides detections at greater range or more detections at a given range a reasonable assumption is that information would be shared, resulting in a higher force effectiveness.

b. No interactive artillery or aviation coordination

Another instance of suppressed information sharing concerns the coordination of combined arms. The simulation was systemically run for a group of scenarios. Artillery was represented by preplanned fires only; aviation routes for Air Force close air support and Army aviation assets were preplanned as well. On an actual battlefield, if the addition or deletion of sensors contributed to more detections or, in particular, detections at greater ranges, artillery may have been called. The effect of additional sensors may be detections at ranges well beyond the tank's main gun capability. If such detections occur it would be reasonable to

request heavy artillery, Air Force close air support, or Army aviation to attrit lead enemy elements at long ranges. Once again, since JANUS(A) does not allow information sharing or conditional mission assignment, the potential increase in force effectiveness or force lethality may not be realized.

c. No intermediate degradations

There are no partial kills such as mobility-only or firepower-only in JANUS(A). If a target is engaged the results are classified as either a catastrophic hit (kill) or a near-miss (suppressed). A suppressed target is incapable of firing for a short period of time, but once the suppression period has expired the weapon system is once again fully capable. Also, there are no "phantom targets", that is, engagements that result from the gunner or tank commander identifying a nonexistent target. Firing at phantom targets is not an uncommon occurrence and can affect ammunition expenditure rates. Finally in this area, once targets are destroyed they may no longer be detected; they are totally removed from the battlefield. The recent Gulf War has shown many examples of targets with tens or even scores of penetrations due to multiple engagement by many firers. Once again, the lack of this realism contributes to ammunition expenditure inaccuracies for both sides.

d. No fratricide

Friendly forces do not "see" each other in JANUS(A). Since no detection of friendly forces occurs no fratricide occurs. The Army is sensitive to the

fratricide issue and studies have been conducted to attempt to add fratricide capabilities to JANUS(A). The version of JANUS(A) used in this thesis was not equipped with the fratricide capability.

e. *No RAM play*

There was no representation of reliability, availability, or maintainability of the weapon systems used in the simulations. A system was 100% operational until suppressed or killed.

B. THE TRAC-MTRY INDEPENDENT SENSOR ALGORITHM

1. Background

The TRADOC Analysis Command-Monterey (TRAC-MTRY) developed a prototype JANUS(A) independent sensor algorithm. The expressed purpose of the algorithm was to support analysis of the CITV.

TRAC-MTRY is interested in enhancing JANUS(A) to more accurately reflect true battlefield conditions. An M1-series tank has a four man crew. Although there are times when all four crewmen can conceivably be searching for targets, in reality the driver and loader are either preoccupied with their respective duties or otherwise hindered by physical limitations from searching for targets. The tank commander and gunner have the primary responsibilities for searching for and acquiring targets. As noted previously, the tank commander is capable of searching independently of the gunner in the current tank configuration, albeit without an independent sight. Ideally, the independent sensor algorithm should be capable of

emulating a wide range of sensor combinations, from unaided vision (exposed tank commander) to the proposed best-case (CITV).

2. Synopsis of Independent Sensor Methodology

The Independent Sensor Algorithm methodology capitalizes on the JANUS(A) technique of allowing systems to be "stacked" or mounted on a "host" system. Using the mounting method, the user identifies which systems are hosts (gunners) and which are riders (commanders). The crux of the enhancements is a group of FORTRAN subroutines, essentially modifications to the original source code, that merge the detected target lists from the mounted and host systems, screen for duplications, and prioritize targets for engagement based on user-defined parameters. Further, weapons capabilities are removed or suppressed from the mounted system, i.e. his firing capability is limited to the weapons systems of the host (gunner). Within JANUS(A), as well as within the military, withholding firing authority is termed "hold fire." The net effect of this technique is that it allows the user to relate up to two more sensors, now independent of the original sensor(s), with the host weapon system. Appendix A lists the specific steps necessary for current JANUS(A) users to implement the TRAC-MTRY Independent Sensor Algorithm. Refinements to the original prototype code were necessary to allow more than one type of commander system to be linked with a gunner system. The modified code is found in Appendix B. Test runs were conducted to ensure all combinations of commander-gunner pairings and the order of entry in the JANUS(A) preparatory screens were valid.

C. ASSUMPTIONS

There are a number of assumptions that must be made in order to attempt to model the combat capabilities of the CITV. First and foremost it is assumed that the JANUS(A) model is an acceptable representation of the battlefield. There are also assumptions to be made concerning the performance of the weapon systems.

1. The TRAC-MTRY Independent Sensor Algorithm is valid

The modifications to JANUS(A) that represent the merging of the target lists were tested by Major James C. Hoffman, Deputy Director, TRAC-MTRY. Additionally, enhancements were made to allow multiple sensor types to be associated with the same host system type. Additional implementation pilot tests were conducted to ensure that detections from the mounted system were being placed on the total system's detected list and that engagements were resulting from the mounted system detections.

2. Tank Commanders and gunners search continuously

This is a JANUS(A) limitation. The Government's General Accounting Office (GAO) [Ref. 3:pp. 35-37] heavily criticized the Army for the methods used to represent the CITV during the M1A2 Cost and Operational Effectiveness Analysis (COEA) conducted in 1989. Specifically, GAO criticized the Army analyst's assumptions that an M1A1 tank commander never searches for targets while an M1A2 tank commander, equipped with a CITV, always searches for targets. This appears to be a reasonable criticism. By using the Independent Sensor Algorithm,

the issue of an M1A1 commander never searching may be resolved. A non-CITV equipped M1A1 is represented by mounting an individual soldier on the host M1A1 and integrating the sensor capabilities of the soldier with the tank. Hence, we have represented the non-CITV tank commander by an integrated, independent optical sensor while the CITV-equipped M1A1 tank commander is represented by the CITV sensor. The remaining drawback is that both sensor systems are assumed to be continuously functioning. There is no degradation due to concurrent duties, sleep, etc. While this limits the realism of the simulation, it provides a much greater degree of realism for performance comparison than was previously available. Further modifications to the underlying detection algorithms could be reasonably accomplished to represent a fractional proportion of actual search-related time.

3. Weapons systems performance characteristics of M1A2 do not transfer same enhancement to a CITV-equipped M1A1

Certain measures of weapon system engagement capabilities are significantly different between the M1A2 and the M1A1. These technical measures have been documented by the Army Materiel Systems Analysis Activity (AMSAA) at Aberdeen Proving Ground. Specifically, there is a measurable difference in the lay time of the weapon systems. The lay time, generally, is the amount of time necessary to move the gun and sights so that the gunner/commander may begin the precision process of aiming the gun. AMSAA has documented a noticeably shorter lay time for the M1A2 system. It was assumed that all of the proposed upgrades for the M1A2 system were in effect during the testing. One cannot assume that the

addition of only one component of the M1A2, the CITV, would contribute the same amount of decrease in the lay time, if any at all. The M1A2 includes a digital electronics structure as well as a different fire control architecture which may have been the predominant reason for the decrease. It is assumed that the CITV contributes no advantage or disadvantage to lay time.

4. There are no special logistical considerations for employing a mixed level of CITVs

Logistics considerations were assumed to not influence battle performance.

5. Tactical scenarios are appropriate

The scenarios were developed from base scenarios already in existence at TRAC-MTRY and the Armor School at Fort Knox. The final forms of the scenarios were the result of personal experience in armor assignments in both Central Europe and the Mojave Desert.

III. STUDY METHODOLOGY

A. SCOPE OF THE STUDY

This thesis examines force performance when different percentages of CITV-equipped tanks are in the force structure. To conduct the study, two basic scenarios were developed: a Central European armor task force defense and a Southwest Asia cavalry regimental defense in sector. No offensive scenarios were developed since it was believed that if any differences were to occur they would be most profound, and therefore most easily measurable, in defensive scenarios.

For each location both a day and night technical database were developed. Three levels of CITV allocation were examined: none, one CITV-equipped tank per platoon or section, and three CITV-equipped tanks per platoon or section. This structure results in a well-balanced experimental design. The general test scheme is summarized in Table I.

B. TEST SCENARIOS

Two scenarios each with the various CITV allocations, are studied. The two geographical areas were chosen due to their diversity. In Central Europe, the terrain limits both acquisition and engagement capability, as well as hindering movement. In Southwest Asia the terrain has only minor impact on the acquisition and engagement process. Stopping criteria were established for each scenario. In both

cases a time limit and a physical boundary were set. The simulation was terminated if the time limit was reached or if the threat forces penetrated the specified gridline with a certain force size. Threat forces were equipped with better than currently fielded equipment. Next-generation tanks and infantry fighting vehicles outfitted with weapons systems such as breach launched anti-armor missile systems were used.

Table I GENERAL TEST SCHEME

LEVEL OF CITV	TERRAIN	DAY vs NIGHT
0	Europe	Day
0	Europe	Night
0	SW Asia	Day
0	SW Asia	Night
1	Europe	Day
1	Europe	Night
[illegible]	SW Asia	Day
1	SW Asia	Night
3	Europe	Day
3	Europe	Night
3	SW Asia	Day
3	SW Asia	Night

1. The Central European Scenario

The Central European scenario battlefield is near the German town of Brietenbach. The terrain is highly compartmentalized, has numerous towns, and is transected by the Fulda river. The area of operations is broken into many small engagement areas, none of which allow for consistent long range engagements. Potential targets are visible for only short periods of time at extended ranges before they disappear behind concealing terrain. The terrain is expected to influence detection capability, tending to make detection (and, by extension, engagement) ranges short. Relative combat power is shown in Table II.

Table II RELATIVE COMBAT POWER, CENTRAL EUROPE

COMBAT POWER: CENTRAL EUROPE SCENARIO			
WEAPON SYS	**BLUE**	**THREAT**	**RATIO**
TANKS	30	40	1:1.333
CFV/IFV	32	93	1:2.906
RECON	0	18	----
OTHER*	41	44	1:1.073
TOTAL	103	195	1:1.893

2. The Southwest Asia Scenario

The Southwest Asia scenario is in a desert area that is very flat. The area has long fields of view with virtually uninterrupted line-of-sight. There are few manmade obstacles and only a small number of towns or urban areas. The terrain is easily trafficable and allows long range detections and engagements. This area represents almost a complete reversal of the hindrances of the Central European scenario. Relative combat power is shown in Table III.

Table III RELATIVE COMBAT POWER, SOUTHWEST ASIA

COMBAT POWER: SOUTHWEST ASIA SCENARIO			
WEAPON SYS	**BLUE**	**THREAT**	**RATIO**
TANKS	38	106	1:2.789
CFV/IFV	41	61	1:1.487
RECON	----	66	----
OTHER*	43	274	1:6.372
TOTAL	122	507	1:4.156

C. ALLOCATION OF CITVs

As shown in Table I, CITV-equipped tanks were added to the force on a one-for-one basis for non-CITV equipped tanks. Initial runs were conducted with no CITVs allocated. The tank commanders were represented by a soldier with naked

eye or binocular-type optical sensors. The tank commander was capable of independent sensing within the given field of regard for the tank. For each scenario runs were conducted after equipping one tank per platoon with a CITV and then three tanks per platoon with CITVs. In the case of non-platoon level tanks, such as company and battalion/squadron commanders, the CITVs were added for both the one per platoon and three per platoon runs.

D. DAY VERSUS NIGHT IN JANUS(A)

The JANUS(A) combat model does not explicitly represent day or night. In order to simulate a weapon systems' capabilities during daytime, darkness, or periods of limited visibility, the user must manipulate the technical parameters that describe a sensor's performance. This is done by changing the values for a sensor's minimum resolvable contrast in cycles per milliradian or minimum resolvable temperature (see Chapter II). The JANUS(A) database was changed to reflect the different technical MRC or MRT curves according to data available in the TRAC-MTRY archives. Thermal sight capabilities were assumed to remain unchanged from day to night, image intensification type sights were set operational at night only, and unaided optical sight sensors were removed or degraded from weapon systems during the night scenarios.

E. DATA COLLECTION

Three replications were conducted for each scenario at each CITV level for a total of 36 replications. Each replication was started with a unique random number seed for all stochastic processes. Collected data elements are shown in Table IV.

Table IV DATA COLLECTION MATRIX

DATA COLLECTION MATRIX			
DATA ELEMENT	CASUALTY DATA	ENGAGEMENT DATA	DETECTION DATA
Scenario Category	X	X	X
Time of Event	X	X	X
Range of Event	X	X	X
Type of Kill	X		
Firer/detect/ Killer Wpn System Type	X	X	X
Victim/Target Wpn Sys Type	X	X	X
Munition Type	X		
Weapon Type		X	
Sensor Type			X
Speed of Firer/Victim		X	

Analysts at TRAC-MTRY have written a concise data collection post-processor for JANUS(A) that significantly eases the data collection and management effort. Further data reduction was done using simple FORTRAN programs (Appendix E) to extract data thought pertinent to this study.

F. MEASURES OF PERFORMANCE/MEASURES OF EFFECTIVENESS

Two principle areas were investigated: the force effectiveness in terms of casualties inflicted or sustained, and changes in detection capability. Both areas are assumed to be influenced by the addition of CITV capability to the tanks in the Blue force. The hypotheses are that the CITV yields greater detection capabilities and that, with these greater capabilities, the Blue forces will inflict more casualties on the enemy while sustaining fewer losses. The following measures of performance (MOP) or measures of effectiveness (MOE) were used to test these hypotheses:

1. Force Effectiveness Measures

a. Absolute Red Losses Inflicted by Blue forces

This is a simple measure, but provides insight into the force's lethality.

- Number of Red Tanks Killed by Blue Tanks
- Number of Red Tanks Killed by All Blue Systems
- Total Number of Red Weapon Systems Killed by all Blue Weapon Systems

b. Absolute Number of Blue Tanks Killed by All Red Systems

This MOE gives a rough indication of force survivability. If the CITV provides enhances detection capability, this MOE should decrease as the number of CITV-equipped tanks increases and the volume of enemy detections increases.

c. Loss Exchange Ratio

This is a measure of blue effectiveness that quantifies both the blue force's capability of inflicting losses and the blue force's own survivability.

$$\text{Loss Exchange Ratio} = \frac{\text{Number of Red Losses}}{\text{Number of Blue Losses}}$$

This is a traditional MOE frequently used when comparing materiel or doctrinal issues.

d. Relative Loss Exchange Ratio

Another widely used MOE, this provides us with a measure that accounts for two major blue force interactions: The numerator is a measure of the blue force's lethality or destructive capability, while the denominator measures blue's survivability. This is traditionally viewed as the measure of force effectiveness. [Ref. 4]

$$\text{Relative Loss Exchange Ratio} = \frac{\dfrac{\text{Number of Red Losses}}{\text{Red Initial Strength}}}{\dfrac{\text{Number of Blue Losses}}{\text{Blue Initial Strength}}}$$

2. Detection Measures

a. *Median Range of Detection and Distribution of Detection Ranges by M1A1 (Blue) Tanks*

General comparisons among the scenarios and levels of CITV are made using graphical techniques such as notched boxplots and histograms. Comparisons of median detection range as well as distributional descriptive statistics are used to determine if the detection capability of the tank force is sensitive to any of the main factors of location, level of CITV, and day versus night.

b. *Median Range of Detection and Distribution of Detection Ranges by Sensor*

Similar to *a.* above, comparisons between sensor types are made using various graphical techniques.

c. *Detection Efficiency Ratio (DER)*

The detection efficiency ratio (DER) is a measure of effectiveness that attempts to determine a sensor's contribution to the total detection capability of a weapon system. The DER is defined as:

$$DER = \frac{\dfrac{\sum NUMBER\ OF\ DETECTIONS\ BY\ SENSOR\ TYPE\ i}{\sum NUMBER\ OF\ DETECTIONS\ BY\ ALL\ SENSORS}}{\dfrac{\sum NUMBER\ OF\ SENSOR\ TYPE\ i}{\sum ALL\ SENSORS}}$$

where sensor types include unaided optical (eye), CITV, gunner's primary sight-optical, and gunner's primary sight-thermal and the summation is over all replications

for a particular location, CITV level and day or night for all targets. The DER measures how well a particular sensor contributes to the volume of detections compared to the percentage of the sensor population belonging to that particular sensor. This measure is useful when making comparisons within the same scenario, but may be influenced by interactions among factors if used to make comparisons between scenarios.

IV. ANALYSIS

This chapter provides the analysis used to determine if adding the CITV enhanced the force effectiveness of the U.S. (blue) units. Two areas are pursued: force effectiveness (both lethality and survivability) and detection capability. Analysis proceeds as an investigation of the raw numbers, graphical displays to ascertain trends, and analysis of variance to determine if measurable differences exist between or among the data sets.

A. DATA

Pertinent data is summarized in tables in Appendices C and D. Data was collected as described in Chapter III.

B. ANALYSIS

1. Force Effectiveness Measures

This section focuses on the traditional measures of effectiveness: average losses for each side, loss exchange ratios (LERs) and relative loss exchange ratios (RLERs).

a. Average Red Tank Losses Inflicted By Blue Tanks

Refer to Appendix C for casualty data. Average red tank losses inflicted by blue tanks were calculated for each cell using simple averages for the three replications. Results are shown in Figure 1. On first inspection it appears that

the M1A1 improves in its ability to kill red tanks as the level of CITV increases in the european scenarios, while performing less effectively in the desert environment.

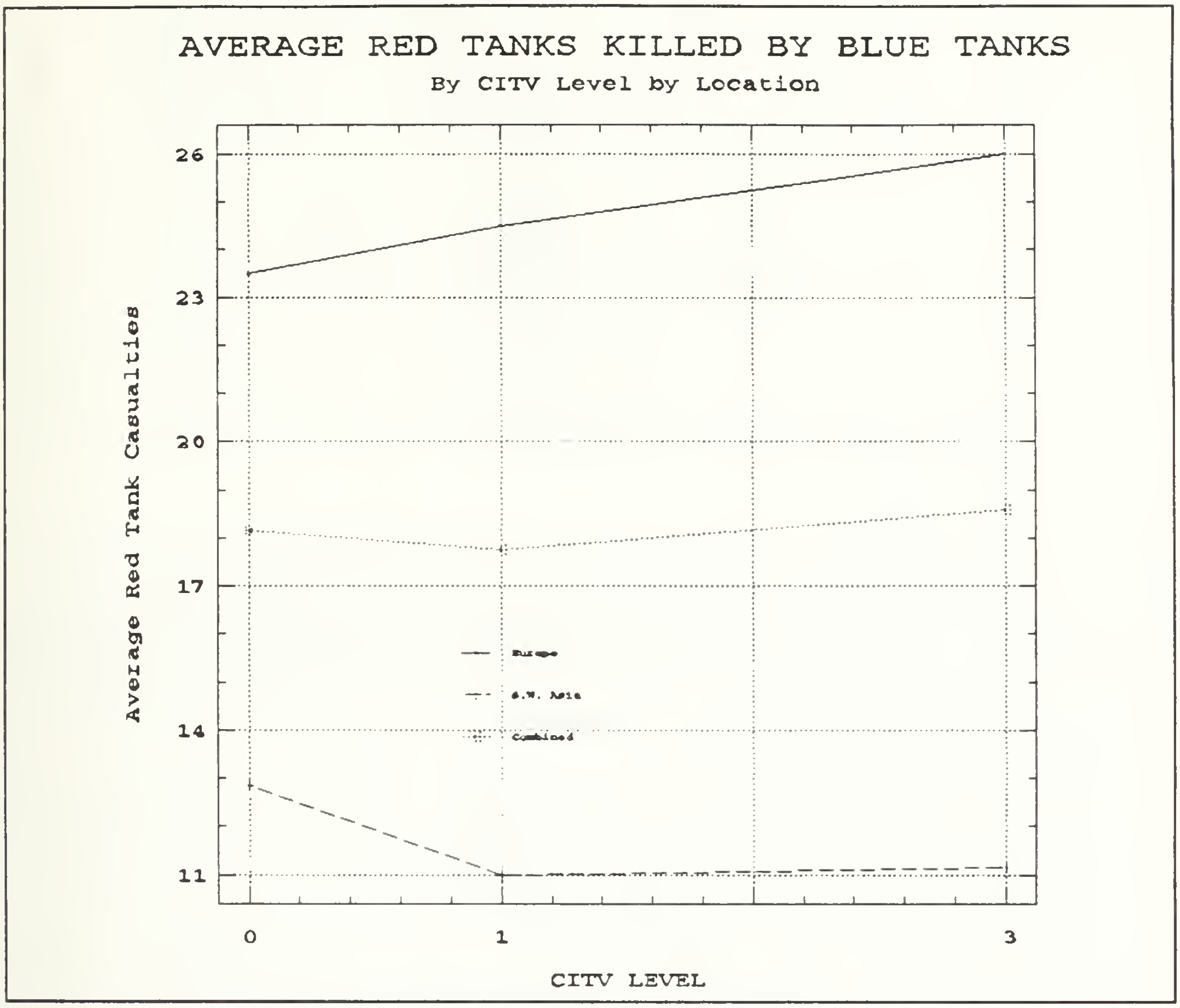

Figure 1 RED TANKS KILLED BY BLUE TANKS

In order to determine if the three factors (CITV level, Day vs Night, and Location) influence the lethality of M1A1s versus red tanks, a three factor ANOVA was performed. Four hypotheses were tested at the $\alpha = 0.05$ level:

1. H'_o: Level of CITV has no effect.

   H'_α: Level of CITV has some effect

2. H''_o: Day vs Night has no effect.

   H''_α: Day or Night has some effect

3. H'''_o: Location has no effect.

   H'''_α: Location has some effect

4. H''''_o: Interaction effects all = 0.

   H''''_α: Some interactions exist.

In each case the null hypothesis is rejected if the F-ratio is greater than the established critical value at the appropriate degrees of freedom. For red tanks killed by blue tanks, hypothesis H'''_o is rejected ($78.146 \gg f_{.05}(2,24)=3.40$); there is strong evidence that there are differences in the number of red tanks killed by blue tanks in the two locations (Europe vs Southwest Asia). Table V shows that two-factor interactions do not appear significant. This is somewhat surprising. One would expect the CITV, with its technical superiority to unaided vision, to be more effective at night and in the desert then in the day or in Central Europe. Finally, H'_o cannot be rejected: the effect of the level of CITV appears *not* to contribute to the number of red tanks killed by M1A1s.

b. Average Red Tank Losses Inflicted By All Blue Systems

An identical approach to that taken in *a.* above is used for the next two sections. Once again, the observer is inclined to believe that the force

Table V ANOVA, RED TANKS KILLED BY BLUE TANKS

Analysis of Variance for RED TANKS KILLED BY BLUE TANKS

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1534.1667	4	383.5417	19.706	.0000
CITV Level	4.1667	2	2.0833	.107	.8989
Day vs. Night	9.0000	1	9.0000	.462	.5097
Europe vs. S.W. Asia	1521.0000	1	1521.0000	78.146	.0000
2-FACTOR INTERACTIONS	62.777778	5	12.555556	.645	.6676
CITV vs. Day/Night	22.166667	2	11.083333	.569	.5727
CITV vs. Location	27.166667	2	13.583333	.698	.5067
Day/Night vs. Location	13.444444	1	13.444444	.691	.4223
RESIDUAL	506.05556	26	19.463675		
TOTAL (CORR.)	2103.0000	35			

0 missing values have been excluded.

effectiveness increases in European scenarios as the number of CITV-equipped M1A1s increases (Figure 2), while remaining nearly unchanged in the desert environment. The ANOVA approach is again employed to determine if the various factors influence the number of red tanks killed. The 5% level of significance critical value of the F-statistic is 3.40 for CITV effects and 4.26 for location effects. Again it is apparent that there are no two-factor interactions, that location is significant, and that the null hypothesis for CITV level contributions cannot be rejected.

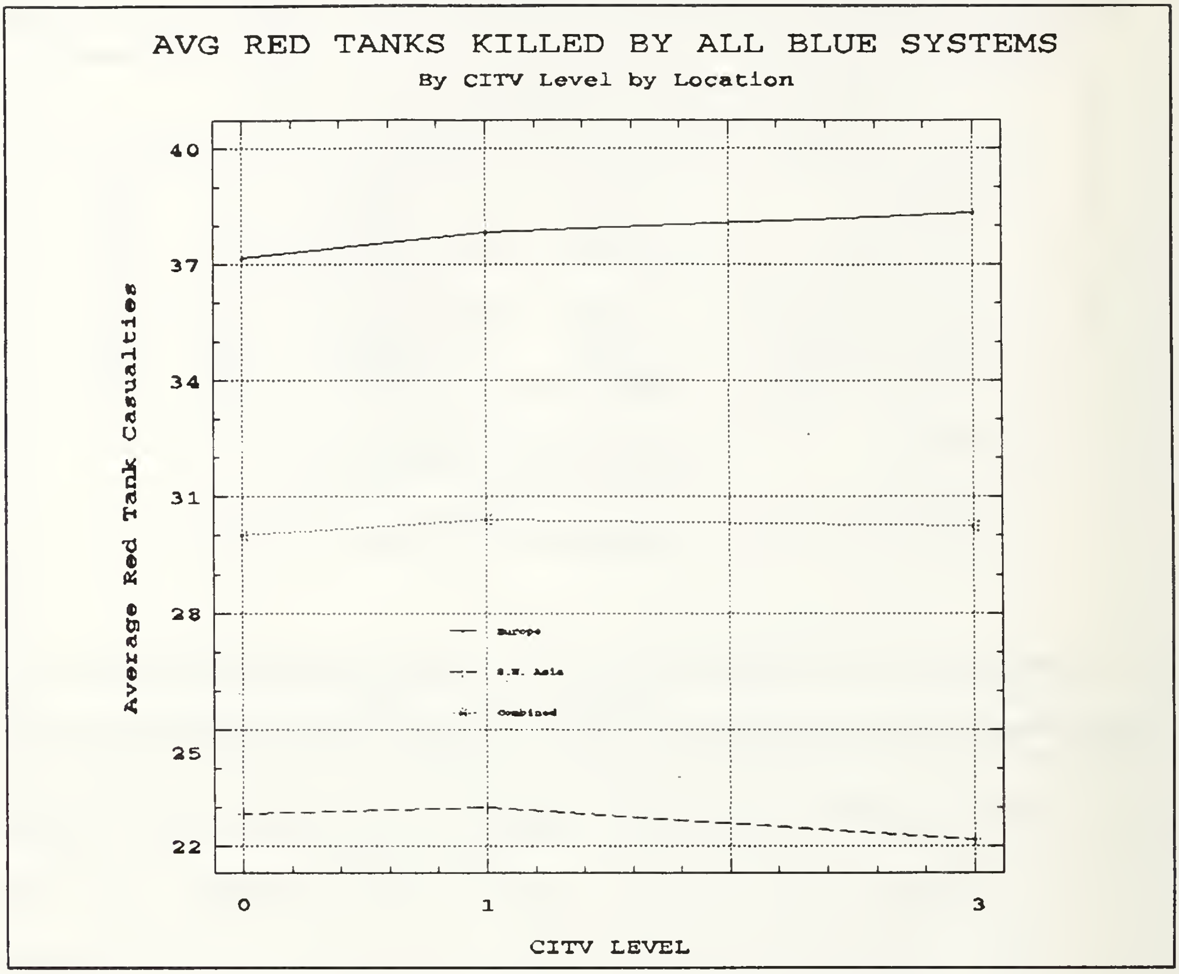

Figure 2 RED TANKS KILLED BY ALL BLUE SYSTEMS

c. *Average Blue Tank Losses Inflicted By All Red Systems*

The survivability of the M1A1 fleet is addressed using the average blue tank losses to all red systems as a measure of effectiveness. Blue M1A1 losses remained nearly constant as CITV-level increased. Using the ANOVA table in Table VII, it is seen that two-factor interactions exist between CITV level and Day/Night even though, as a main effect, CITV is not significant. This may be attributable to high influence from the CITV European night scenarios. Two of the three observations are much lower than any other scenario. This significant

Table VI ANOVA, RED TANK LOSSES TO ALL BLUE SYSTEMS

Analysis of Variance for RED TANKS KILLED BY ALL BLUE SYSTEMS

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	2063.2778	4	515.8194	40.027	.0000
CITV Level	1.0556	2	.5278	.041	.9599
Day vs. Night	7.1111	1	7.1111	.552	.4721
Europe vs. S.W. Asia	2055.1111	1	2055.1111	159.475	.0000
2-FACTOR INTERACTIONS	79.888889	5	15.977778	1.240	.3192
CITV vs. Day/Night	52.722222	2	26.361111	2.046	.1496
CITV vs. Location	5.388889	2	2.694444	.209	.8127
Day/Night vs. Location	21.777778	1	21.777778	1.690	.2050
RESIDUAL	335.05556	26	12.886752		
TOTAL (CORR.)	2478.2222	35			

0 missing values have been excluded.

departure is probably a result of variability or random chance that two very low results were found in the same cell. As before, location has great influence on the performance and, in this instance, there is significance in the day versus night scenarios.

d. Loss Exchange Ratios

The loss exchange ratio (LER) is presented for completeness. As noted in Chapter III, the LER provides a rough measure of the killing efficiency of a force. Data presented in Table VIII and Figure 3 show an increase in LER when one CITV is added per platoon but no corresponding increase when the CITV level is three per platoon. The case of Southwest Asia shows that the LER is higher for three CITV per platoon than for none, however when the performance increase is

Table VII ANOVA, BLUE TANK LOSSES

Analysis of Variance for Blue Tank Losses from All Red Systems

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1587.0000	4	396.7500	50.525	.0000
Level of CITV	7.3889	2	3.6944	.470	.6299
Day vs Night	173.3611	1	173.3611	22.077	.0001
Europe vs S.W. Asia	1406.2500	1	1406.2500	179.082	.0000
2-FACTOR INTERACTIONS	129.80556	5	25.961111	3.306	.0192
CITV vs. Day/Night	104.38889	2	52.194444	6.647	.0047
CITV vs. Location	5.16667	2	2.583333	.329	.7226
Day/Night vs. Location	20.25000	1	20.250000	2.579	.1204
RESIDUAL	204.16667	26	7.8525641		
TOTAL (CORR.)	1920.9722	35			

0 missing values have been excluded.

considered with the analysis of the previous sections the conclusion remains that the level of CITV does not contribute to a dramatic increase in force effectiveness.

e. *Relative Loss Exchange Ratios*

The relative loss exchange ratio (RLER) is considered a good measure of both the force's effectiveness in inflicting casualties as well as indicating the force's survivability. Table IX and Figure 4 present the findings for RLER. The large drop in RLER for the European scenarios with three CITV per platoon is attributed to both the overall increase in blue losses and a marginal decrease in the efficiency of killing red systems. RLER is consistent with all other measures used; increasing the level of CITV does not correspond to an increase in the RLER.

Table VIII LOSS EXCHANGE RATIO

LOSS EXCHANGE RATIO (LER)		
CITV LEVEL	LOCATION	LER
0	EUROPE	2.449
1	EUROPE	2.577
3	EUROPE	2.380
0	S.W. ASIA	2.471
1	S.W. ASIA	2.651
3	S.W. ASIA	2.616
0	COMBINED	2.462
1	COMBINED	2.619
3	COMBINED	2.509

2. Detection Capability

This section explores whether the addition of the CITV influences the tank's detection capability. Detection range, number of detections, and the distribution of detection ranges are used to examine two areas: the model's representation of the integrated sensors' capabilities and what impact, if any, the addition of the CITV had on detection capabilities.

a. Representation of Tank Commander and CITV

The number of detections, detection range, and day versus night differences between the CITV and the surrogate tank commander show that the technical capabilities of the CITV are well-represented in JANUS(A). Figure 5 displays a composite representation of the performance of all sensors. Notched

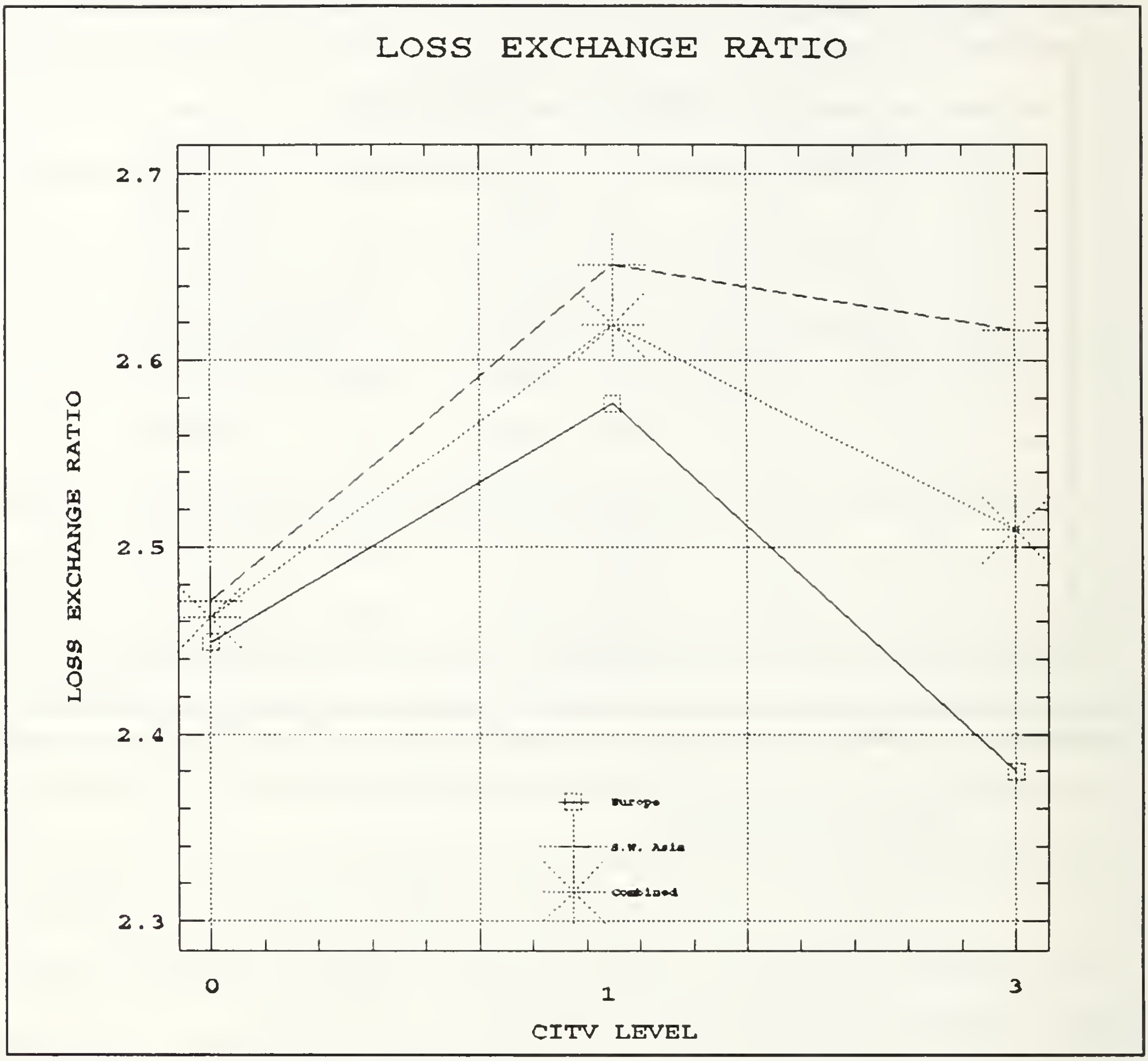

Figure 3 LOSS EXCHANGE RATIO

boxplots may be used as a data analysis tool to compare the medians of various sample populations. [Ref. 5:p. 62] Sample size is represented by the width of the boxes. Non-overlapping notches are strong evidence that the means of the two samples are not equal. The notched boxplot clearly shows that the volume of detections is greater for the CITV than the unaided tank commander (eye) even though the aggregate ratio of unaided tank commander sensors to CITV was 1.56:1.

Table IX RELATIVE LOSS EXCHANGE RATIO

RELATIVE LOSS EXCHANGE RATIO (RLER)		
CITV LEVEL	LOCATION	LER
0	EUROPE	1.294
1	EUROPE	1.361
3	EUROPE	1.257
0	S.W. ASIA	1.100
1	S.W. ASIA	1.180
3	S.W. ASIA	1.168
0	COMBINED	1.181
1	COMBINED	1.256
3	COMBINED	1.204

Although there are fewer CITV systems represented in the scenarios, they account for more total detections than the unaided tank commander. The median detection range for the CITV is well above that for the eye, and the notches of the boxplots do not overlap. The non-overlapping notches are a good indication that differences exist between the performance of the CITV and the unaided tank commander. Investigation of performance segregated by location or day versus night shows similar patterns of behavior.

The percentage of detections attributed to each sensor indicates that the CITV returns more detections per sensor than the unaided tank commander. Table X shows the percentage of total blue tank detection systems attributed to either the CITV or the unaided tank commander as well as the percentage of all detections

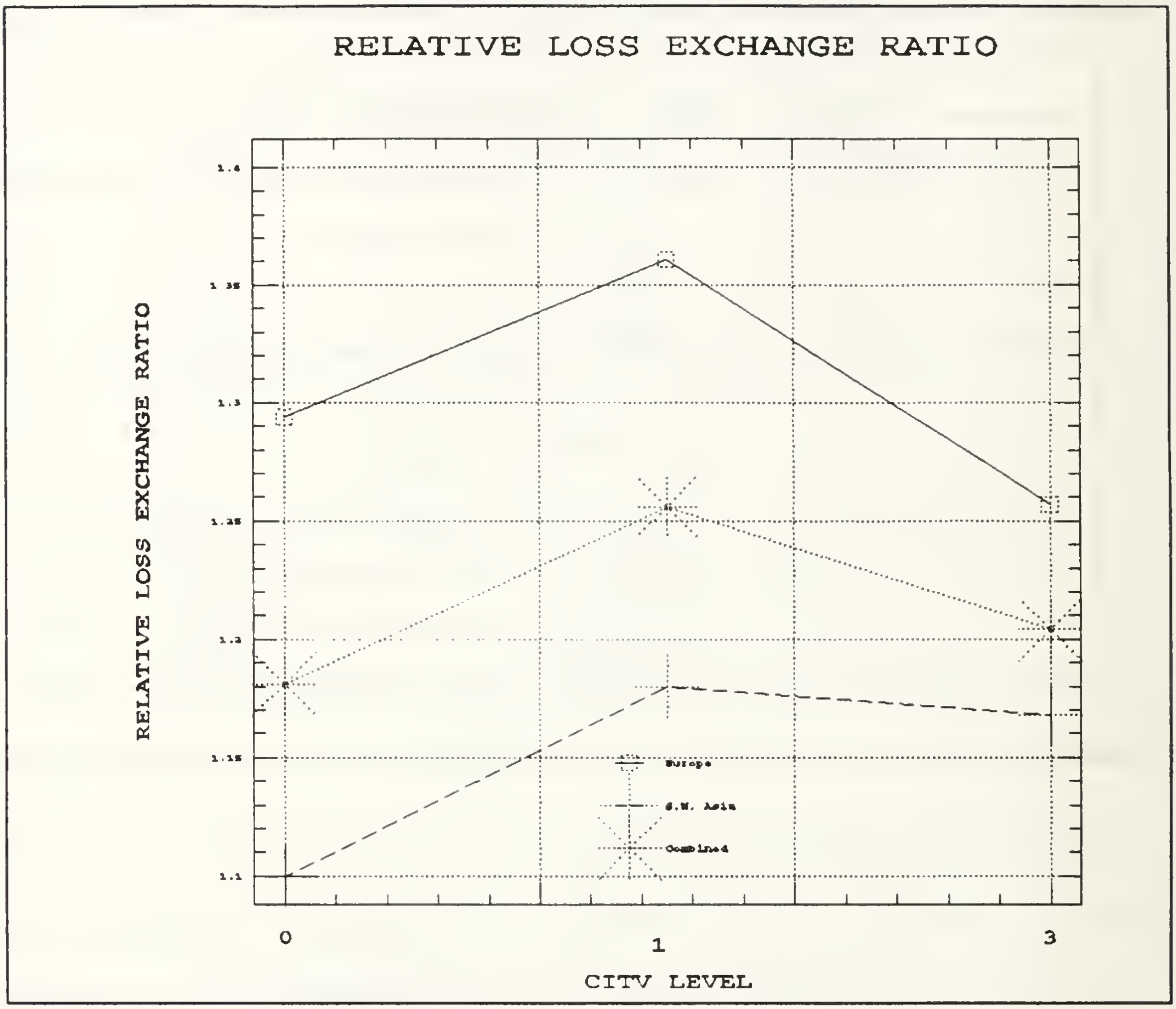

Figure 4 RELATIVE LOSS EXCHANGE RATIO

credited to either sensor. Table XI displays the detection efficiency ratio (DER). The DER is a measure of how well the sensor contributes to detections relative to the number of sensors in the total sensor inventory. A value of one indicates that the sensor is contributing the same proportion of detections as its percentage of total sensors. A sensor that is very efficient could, theoretically, have a DER greater than one, while a poorer performer may have a very low DER. The DER gives an indication of how well a sensor performs under specific circumstances, such as

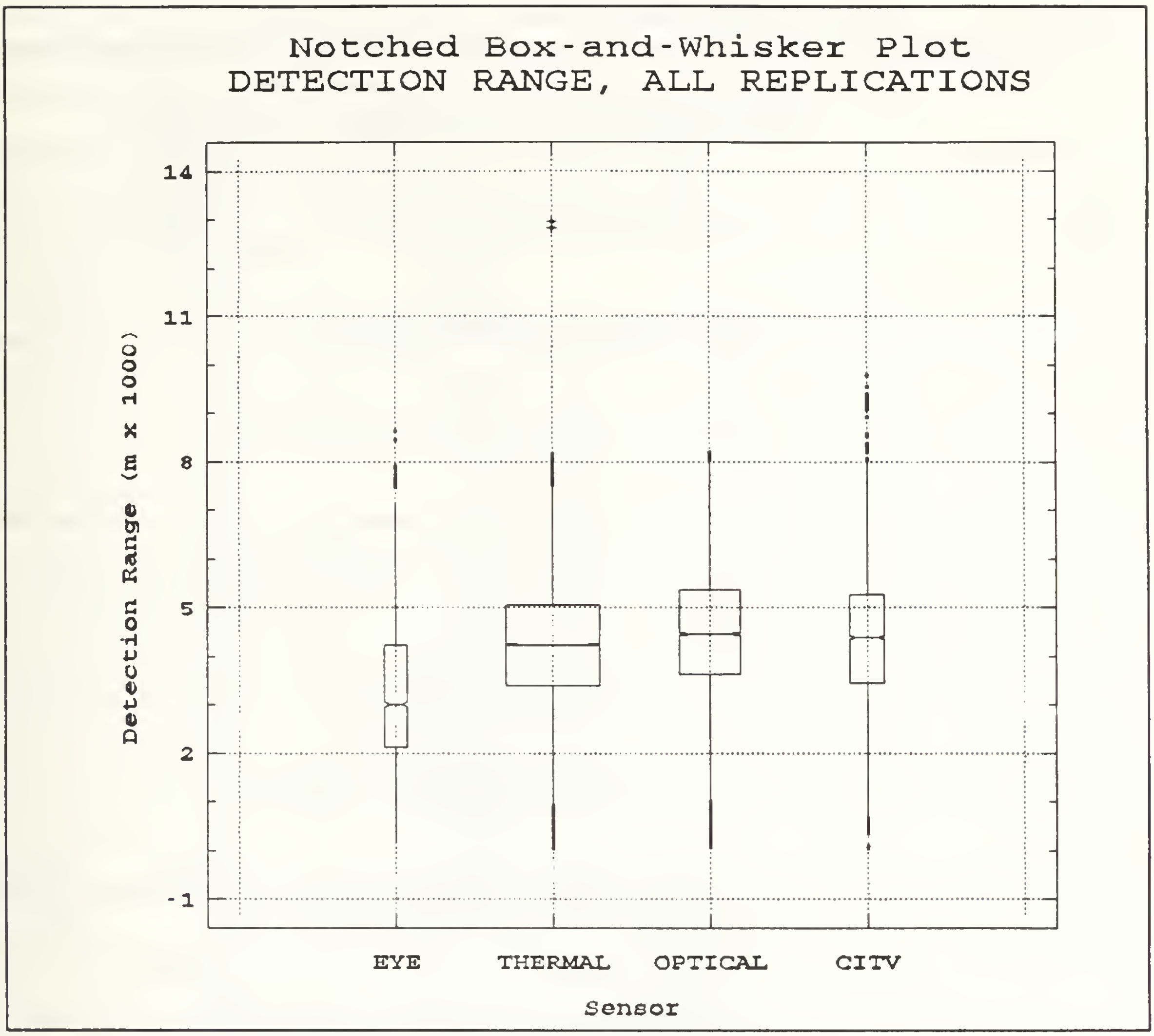

Figure 5 DETECTION RANGE BY SENSOR

location or environment. These differences are readily apparent in Table XI. The performance in Central European scenarios of the CITV is mixed. The unaided tank commander has a higher DER than the CITV in two of the four scenarios. This may be attributable to the more broken terrain, intermittent line of sight, and closer

Table X SENSOR PERFORMANCE

TANK COMMANDER/CITV SENSOR PERFORMANCE						
LOC	DAY/ NIGHT	CITV LEVEL	TC PERCENTAGE OF ALL SENSORS	CITV PERCENTAGE OF ALL SENSORS	PERCENT OF ALL DETECTIONS BY TC	PERCENT OF ALL DETECTIONS BY CITV
EUROPE	DAY	0	33.33	0.00	16.20	---
		1	22.22	11.11	11.83	3.06
		3	7.77	25.55	2.59	12.20
	NIGHT	0	33.33	0.00	25.29	---
		1	22.22	11.11	18.78	6.09
		3	7.77	25.55	5.07	17.66
SWASIA	DAY	0	33.33	0.00	1.37	---
		1	22.76	10.56	3.18	1.83
		3	3.25	30.08	1.11	13.80
	NIGHT	0	33.33	0.00	2.77	---
		1	22.76	10.56	5.90	3.88
		3	3.25	30.08	1.18	26.60

Table XI DETECTION EFFICIENCY RATIO

DETECTION EFFICIENCY RATIO (DER)				
LOC	DAY/NIGHT	CITV LEVEL	CITV DER	TC DER
EUROPE	DAY	0	0.0	**.4860**
		1	.2754	**.5324**
		3	**.4775**	.3333
	NIGHT	0	0.0	**.7587**
		1	.5481	**.8541**
		3	**.6911**	.6525
SWASIA	DAY	0	0.0	**.0411**
		1	**.1733**	.1397
		3	**.4588**	.3415
	NIGHT	0	0.0	**.0831**
		1	**.3674**	.2592
		3	**.8636**	.3631

detection ranges. In all four of the comparable categories in Southwest Asia scenarios the DER for the CITV is much higher than the unaided tank commander.

b. General Detection Performance

Figure 6 and Figure 7 display representative distributions of the detection ranges. The specific distributions for CITV level or day versus night differ little within locations but differ significantly between Central Europe and Southwest Asia. The spikes at approximately eighteen hundred meters and twenty-five hundred meters in Figure 6 correspond to the terrain pattern found in the Central European scenarios. The distribution seen in Figure 7 shows a significantly different distribution of detection ranges. The detections begin almost immediately at the maximum visibility range of six kilometers, with a few outliers beyond eight kilometers. The relatively flat, unbroken terrain of the Southwest Asia scenarios provides excellent visibility and allows the optimal use of both the optical and thermal sights. Clearly, the large numbers of detections occur well beyond the M1A1's main armament's maximum range approximately 3,500 meters. Again, the distributions within the Southwest Asia scenarios differ little from Figure 7. In both the Central European scenarios and the Southwest Asia scenarios differences in distributions appear as changes in kurtosis; the distribution shifts a proportion of the tail generally from shorter ranges in non-CITV cases to somewhat longer ranges with three CITVs per platoon.

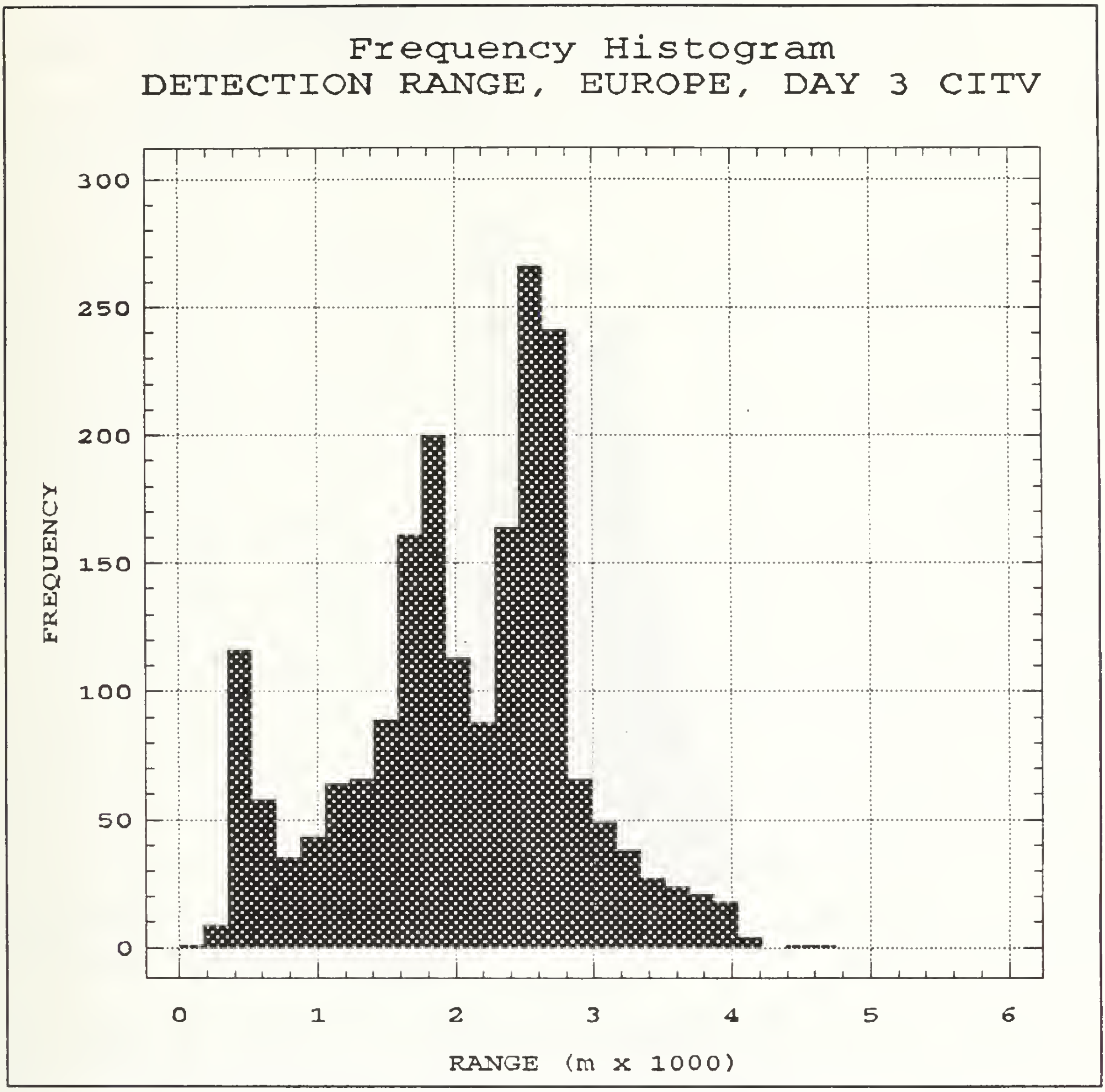

Figure 6 DETECTION RANGES, CENTRAL EUROPE

c. *Contributions By the CITV*

Figure 8 summarizes the three main factors and the impact on detection ranges. Clearly, the ranges of detection are much longer for Southwest Asia scenarios than Central European. It also is apparent that the median range and interquartile ranges do not vary substantially within the Central European scenarios.

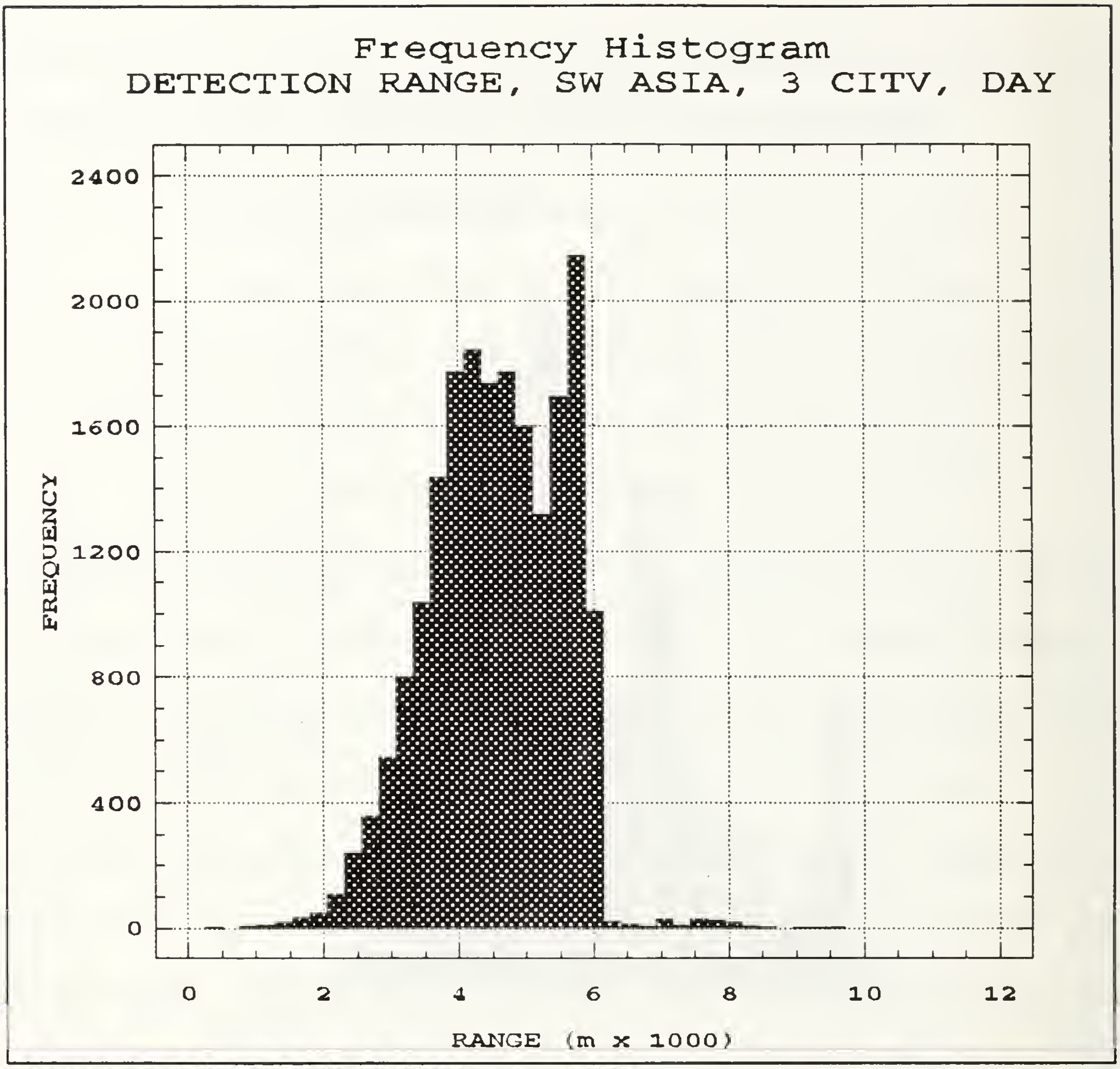

Figure 7 DETECTION RANGES, SW ASIA

In the desert, however, differences do appear and can be attributed to the level of CITV. Both Figure 8 and Figure 5 show a significant number of detections for the CITV beyond eight kilometers. In fact, nearly all detections beyond eight kilometers are from the CITV. The CITV is contributing in the Southwest Asia scenarios, however, because of the limitations addressed in Chapter II, the model is unable to exploit the greater detection ranges and better intelligence: the additional detections

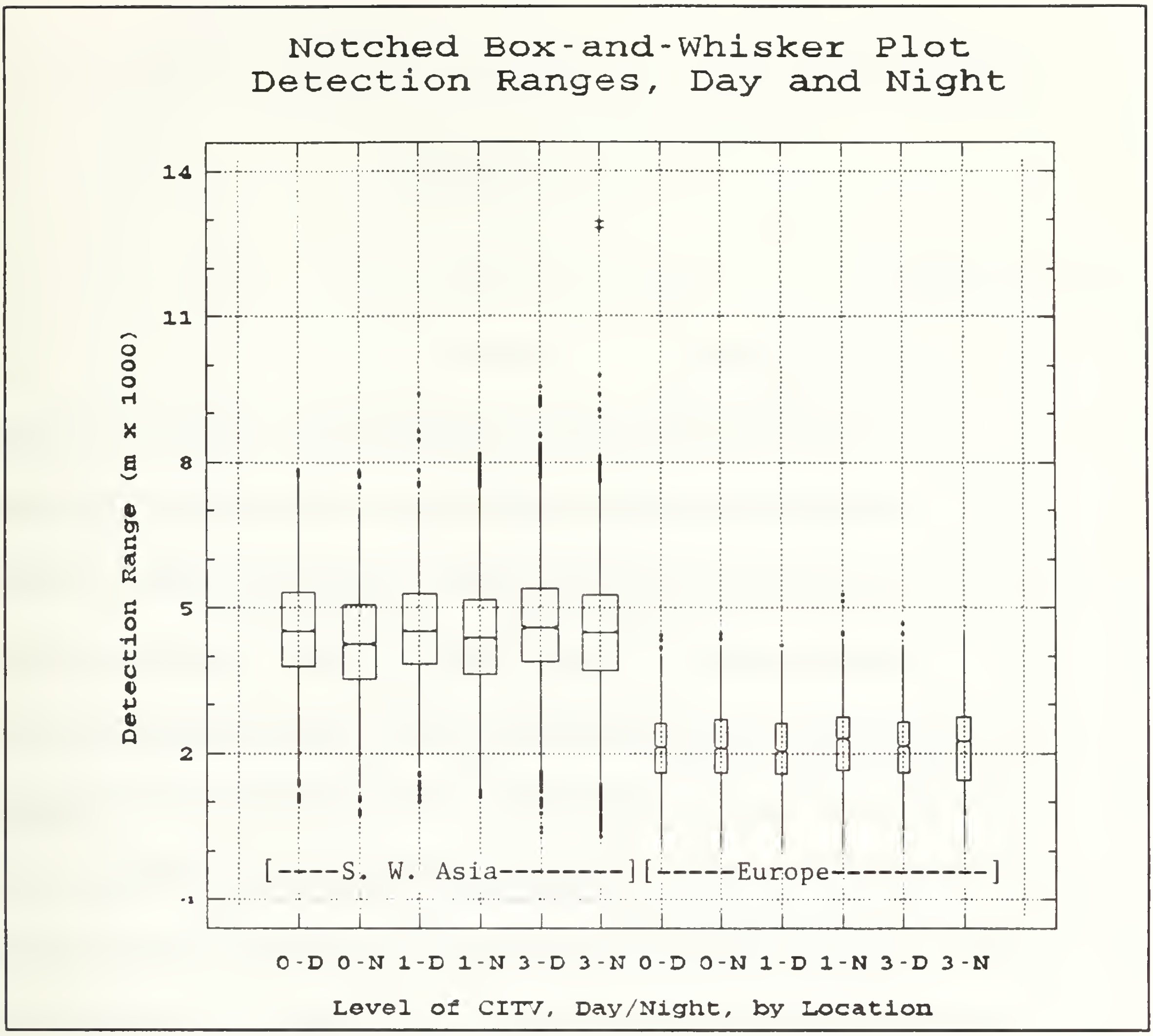

Figure 8 DETECTION RANGES

are beyond the engagement capability of the weapon system.

V. CONCLUSIONS

A. GENERAL

1. Detection Capability

The use of the TRAC-MTRY independent sensor algorithm is a better representation of detection capability for multi-sensor weapons systems than currently available in JANUS(A). Using the independent sensor methodology, the CITV enhances the detection capability of the M1A1 tank. When allocated at the three CITV per platoon level, the detection efficiency ratio in all scenarios is far superior to the detection performance of the unaided tank commander. In the long range detection scenarios of Southwest Asia, the CITV is particularly effective. It is reasonable to conclude that in locations which afford long lines of sight and good visibility that the CITV will contribute significantly to the volume of detections for the tank. During darkness or limited visibility, the CITV-equipped tank clearly outperforms the tank with an unaided tank commander. Both volume of detections and ranges of detections are higher for CITV equipped scenarios.

2. Lethality and Survivability Issues

The increase in the number of detections and detection range does not translate to greater force effectiveness within the JANUS(A) combat model. There is no increase in lethality as measured by the loss exchange ratio, relative loss exchange ratio, or force effectiveness measures. No appreciable difference in the

number of inflicted casualties is supported by the data. There may be many reasons for this result. The limitations of the JANUS(A) combat model, as outlined in Chapter II, bear directly on these conclusions. Although the tanks are capable of seeing more targets, in some scenarios at much greater ranges, the combat model does not exploit the additional information. The frequency histogram of detection ranges in Southwest Asia (Figure 7) clearly shows a large number of detections between three thousand and six thousand meters. The distribution of engagement ranges confirms that targets may be detected but are not being engaged. These ranges of detection are well beyond the main armament capability of the M1A1 tank and therefore are not exploitable by the weapon system. The tank has more than sufficient targets on its target list by the time forces close within main gun range; the tank cannot save earlier detections because of the number of targets presented by the superior red force ratios. The lack of information sharing in the current configuration of the M1A1 as well as the current weapons capabilities limit the simulation's ability to discriminate a contribution to the force effectiveness.

B. AREAS OF FURTHER STUDY

Further research should be directed along two avenues: first, conduct detailed analyses of the underlying algorithms of the JANUS(A) combat model as used in this thesis and, second, explore weapon system enhancements such as breach-launched anti-armor missile systems to possibly capitalize on the greater detection ranges afforded by the addition of the CITV.

Analyses of the technical parameters and underlying algorithms of JANUS(A) are particularly important. Perhaps the model is very sensitive to changes in technical parameters such as aim time and lay time that were assumed unaffected in this thesis. It may be possible that minor adjustments to the weapons system performance attributes cause significant changes in the lethality of the tank. Application of the methodology outlined in this thesis with carefully validated and appropriate classified technical performance parameters for both the US forces and threat forces should also be accomplished.

Additional enhancements to the independent sensor algorithm should also be pursued. As noted earlier, the assumption that tank commanders are continuously searching is unrealistic. Modifications to the independent sensor algorithm or to the existing JANUS(A) detection schemes may result in a more realistic portrayal of the true time allocated to target detection by an actual vehicle or weapon system commander.

APPENDIX A

IMPLEMENTATION STEPS FOR TRAC-MTRY INDEPENDENT SENSOR ALGORITHM

The following instructions allow installation of the TRAC-MTRY Independent Sensor Algorithm in the JANUS(A) combat model.

I. Copy the appropriate JSCRN???.DAT file and rename it JSCRN???.OLD. The execute the program FIXUPJSCN.EXE to ensure the appropriate JANUS(A) interface menus are available.

II. Enter the Combat Systems Database (COMSYS.DAT) file.

a. Modify the systems characteristics (select option SY), if necessary, to set HOST CAPACITY for Commander's system to (1) and Gunner's system to (2). This allows the Commander's system to be mounted on the Gunner's system.

b. Verify the Detection Data (option DD) and set both primary and secondary sensors for the Gunner and Commander systems.

c. Select Weapon Selection (FF) and set firing priorities for the Commander's systems to (0). (Alternatively, set all Commander systems to HOLD FIRE using the interactive screen *after* executing the scenario.

d. Return to JANUS(A) Main Menu.

III. Build or modify the appropriate force files FF from JANUS(A) Main Menu). The Commander/Gunner pair must be adjacent entries in the force file, with the Commander weapon system type preceding the Gunner weapon system type.

IV. Execute your JANUS(A) scenario. (Select EE from JANUS(A) Main Menu).

a. Four JANUS(A) menu screens now exist rather than three. The fourth screen allows the user to indicate which commander/gunner pairs to match for the scenario. Up to five pairs per side are allowed.

b. The interactive screen will initialize with duplicate weapon system symbols, one for the commander and one for the gunner, on the screen. Verify that the Commander systems are in HOLD FIRE. Use the MOUNT command to place the Commander systems on the Gunner systems. Ensure that the correct pairing is matched, i.e. that the preceding Commander system in the Force File is mounted on the subsequent Gunner system. (e.g. system 35 is mounted on system 36).

V. Your JANUS(A) scenario is now ready to run using the TRAC-MTRY Independent Sensor Algorithm. Weapon system performance and maneuver will function as any mounted system in standard JANUS(A). Field of regard for the Commander will be limited to the field of regard of the Gunner, however, the detections will be integrated.

APPENDIX B
INDEPENDENT SENSOR INITIALIZATION FORTRAN CODE

```
C------ SUBROUTINE--INITCITV ---------------- J.C.HOFFMAN, TRAC-MTRY
C                                        DEC 91
C -------------------------------------------MODIFIED 30 APRIL 92
C--------------------------------------------- J.K. WOOD, NPS
C

  SUBROUTINE INITCITV

C-----------------------------------------------------------------C
C
C PURPOSE:  To build and initialize an array of pointers which
C      indicate which unit correspond to systems with
C      "Independent" sensors such as the CITV.
C
C    Independent sensors are portrayed by defining
C    one unit as the "Commander's" system and one
C    unit as the "Gunner's system.
C
C    In the FORCE definition file, the Gunner's Unit
C    must immediately follow the entry for the Commander's
C    unit.
C
C    On Janus Screen IV, the CSD System number (types) of
C    the Commanders' weapon system definitions must be
C    paired to the corresponding CSD System numbers
C    of the Gunners' weapon system definition.  Five
C    pairings are possible for each side.
C
C    During the Planning Phase, the appropriate Commander's
C    Unit must be set to HOLDFIRE (if the Commanders's
C    system definition has weapons which can fire) and
C    MOUNTED on the appropriate Gunner's Unit.
C
C    EXAMPLE:
C          If Commander's Unit number = 4,
C       then it must be mounted on Unit number 5.
C       Unit 5 must be a Gunner's System which is
C       paired to the system type of unit 4, (the
C       Commander's system) on Janus Screen IV.
```

```
C
C****** USE ONLY WITH GROUND SYSTEMS WHERE COMMANDER'S
AND
C    GUNNER'S SENSORS ARE OPTICAL OR FLIR
C
C ******  ALGORITHIM IS NOT TESTED TO WORK WITH LASER

C               DESIGNATOR,
C    RADAR SENSOR/CUEING OR FLYER TYPE UNITS
C
C
C-----------------------------------------------------------------C
C                                                                  C
C-----------------------------------------------------------------C
C ******MODIFICATIONS ALLOW MULTIPLE CDR-GNR PAIRINGS,
     THAT IS, A GUNNER SYSTEM TYPE MAY HAVE MULTIPLE UNITS
     EACH WITH DIFFERENT COMMANDER TYPES
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

   INCLUDE      'JGLOBE:GLOBAL.FOR'
   INCLUDE      'JGLOBE:GLOBUNITS.FOR'
   INCLUDE      'JGLOBE:GLBCITV.FOR'

   DO 300 KSIDE = 1, NUMSIDES

   DO 200 KUNIT = 1, KNUMUNITS(KSIDE)

C -- Set up Data consistency checking values

      KCURCSD = KCSDTYP( KUNIT,KSIDE )!CSD type of current unit
      IF ( KUNIT .GT. 1 ) THEN
        KPREVCSD = KCSDTYP( KUNIT-1,KSIDE )!CSD type of previous
C                     !system
      ELSE
        KPREVCSD = 0    !Set previous CSD to zero
C              !for the FIRST unit (i.e., KUNIT = 1)
      ENDIF

C -- Set up flags for each unit which indicate the type of system
C
C    0 = Normal Janus unit (No independent sensor)
C    1 = Unit is a Gunner's system of an independent sensor pair
C       -1 = Unit is a Commaner's system of an independent sensor pair
```

```
C TYPE *, KUNIT,KSIDE, KCURCSD,KPREVCSD

      DO 100 K = 1, 5  !Five is the current number of independent
C            !sensor system pairs possible on Janus Screen IV
C TYPE *, IPAIR(KSIDE,K,1),IPAIR(KSIDE,K,2)

C       ---- Determine if current unit is designated as a commander

        IF ( KCURCSD .EQ. IPAIR( KSIDE,K,1) ) THEN
C      !Current unit is a Commander's independent sensor system

C -- Check of data consistency error

            IF ( KUNIT .EQ. KNUMUNITS(KSIDE) ) THEN

   TYPE *, 'INDEPENDENT SENSOR DEFINITION ERROR
******'!Commander cannot be
   TYPE *, '  COMMANDER SYSTEM NOT PAIRED WITH GUNNER' !the
last unit in
   TYPE *, KSIDE,' = SIDE',KUNIT,' = UNIT'
          !Force definition

               ENDIF

            KSYSCHAR( KUNIT,KSIDE ) = -1
   !Set Commander flag
C TYPE *, 'KSYSCHAR = ',KSYSCHAR(KUNIT,KSIDE)
            GOTO 200        !Consider next unit

        ENDIF

100      CONTINUE

C       ---- Determine if unit is a gunner

      DO 105 KK=1,5

            IF ( KCURCSD .EQ. IPAIR( KSIDE,KK,2) ) THEN
C      !Current unit is a Gunner's independent sensor system

C -- Check of data consistency error

               IF  (KUNIT .EQ. 1)  THEN
```

```
C    !Gunner cannot be the first defined unit
C

   TYPE *, 'INDEPENDENT SENSOR DEFINITION ERROR ******'
   TYPE *, '  GUNNER SYSTEM CANNOT BE FIRST UNIT IN FORCE
FILE'
   TYPE *, KSIDE,' = SIDE',KUNIT,' = UNIT'

            GOTO 200 ! Consider next unit.  Flags for
C                ! merged tgt list processing will
C                ! NOT be set.  Error in FORCE file
C                ! will default Independent sensor
C                ! system to the Gunner's system.
C                ! Commander's Target Acquision will
C                ! have no influence in this case.

                  ENDIF

C     ----- Check if previous unit is a valid commander, if YES, then
C           check if the previous unit is a valid match to the gunner

                  DO 110 KKK=1,5

                IF(( KPREVCSD .EQ. IPAIR(KSIDE,KKK,1)) .AND.
   +            (IPAIR(KSIDE,KKK,2) .EQ. IPAIR(KSIDE,KK,2)))THEN

                KSYSCHAR( KUNIT,KSIDE ) = 1 !Set Gunner flag
C TYPE *, 'KSYSCHAR == ',KSYSCHAR(KUNIT,KSIDE)
             IPAIRMAP( KUNIT,KSIDE ) = KPREVCSD !Set flag
C                     !defining Cdr
C                     !CSC system type
C                     !for this gunner.
             GOTO 200   ! Consider next unit

               ENDIF
110                CONTINUE

C     --------- If no valid match then an error condition exists
C               Gunner not paired with a valid commander
C
```

```
        TYPE *, 'INDEPENDENT SENSOR DEFINITION ERROR
***********'
        TYPE *, '  GUNNER SYSTEM NOT PAIRED WITH A VALID
COMMANDER'
        TYPE *, KSIDE, ' = SIDE', KUNIT, ' = UNIT'

                      GOTO 200      !Check next unit

                    ENDIF

105               CONTINUE

C       --------  Otherwise, the current unit is not designated as either
C                  a commander or a gunner.  Set system flag to 0.
C


        KSYSCHAR( KUNIT,KSIDE ) = 0 !Set normal Janus Unit flag
C TYPE *, 'KSYSCHAR === ', KSYSCHAR(KUNIT,KSIDE)


C TYPE *, KSIDE,' = KSIDE',KUNIT,' =
KUNIT',KSYSCHAR(KUNIT,KSIDE)
  200       CONTINUE   !Over all units
  300     CONTINUE     !For all sides

   RETURN
   END
```

APPENDIX C

CASUALTY DATA SUMMARY REPORTS: SCENARIOS

CASUALTY DATA SUMMARY REPORT: EUROPEAN SCENARIOS								
EUR/ SWA	DAY/ NIGHT	CITV/ PLT	REP #	RED TANK KILLS BY BLUE TANKS	RED TANK KILLS BY ALL BLUE	ALL RED KILLS BY ALL BLUE	BLUE TANK KILLS BY ALL RED	ALL BLUE KILLS BY ALL RED
EUROPE	DAY	0	1	19	37	108	20	50
			2	25	40	107	17	45
			3	21	36	100	19	50
		1	1	24	39	116	20	51
			2	19	37	101	19	49
			3	28	40	108	19	50
		3	1	23	38	107	19	49
			2	31	38	101	19	50
			3	22	38	109	16	47
	NIGHT	0	1	21	34	104	11	33
			2	30	38	111	15	41
			3	25	38	102	14	39
		1	1	24	35	101	13	40
			2	23	39	114	9	32
			3	29	37	112	8	31
		3	1	25	38	117	13	37
			2	26	38	106	16	44
			3	29	40	105	16	44

CASUALTY DATA SUMMARY REPORT: S.W. ASIA SCENARIOS									
FUR/ SWA	DAY/ NIGHT	CITV/ PLT	REP #	RED TANK KILLS BY BLUE TANKS	RED TANK KILLS BY ALL BLUE	ALL RED KILLS BY ALL BLUE	BLUE TANK KILLS BY ALL RED	ALL BLUE KILLS BY ALL RED
S. W. ASIA	DAY	0	1	9	20	127	27	56
			2	19	27	153	26	57
			3	19	27	153	26	57
		1	1	7	19	139	36	64
			2	12	17	142	33	62
			3	8	20	143	27	54
		3	1	13	27	158	30	56
			2	12	21	146	27	56
			3	7	15	145	35	63
	NIGHT	0	1	10	21	144	31	60
			2	10	21	144	31	60
			3	10	21	144	31	60
		1	1	12	25	143	27	52
			2	10	26	146	25	51
			3	17	31	154	20	44
		3	1	3	15	130	26	52
			2	12	27	139	26	51
			3	20	28	140	24	50

APPENDIX D

SUMMARY DATA/STATISTICS FOR DETECTIONS

DAYLIGHT CENTRAL EUROPEAN SCENARIOS

	0 CITV	1 CITV	3 CITV
Variable:	DETECT RANGE	DETECT RANGE	DETECT RANGE
Sample size	1897	1927	1963
Average	2.06784	2.04242	2.06946
Median	2.13	2.048	2.156
Mode	0.628	0.628	0.595
Geometric mean	1.85313	1.83633	1.84277
Variance	0.645132	0.607982	0.669777
Standard deviation	0.803201	0.779732	0.818399
Standard error	0.0184413	0.0177625	0.0184716
Minimum	0.07	0.07	0.082
Maximum	4.428	4.236	4.667
Range	4.358	4.166	4.585
Lower quartile	1.595	1.576	1.597
Upper quartile	2.624	2.618	2.635
Interquartile range	1.029	1.042	1.038
Skewness	-0.194967	-0.209897	-0.265939
Standardized skewness	-3.46672	-3.76159	-4.81024
Kurtosis	-0.169832	-0.196124	-0.256209
Standardized kurtosis	-1.5099	-1.75738	-2.31712

NIGHT CENTRAL EUROPEAN SCENARIOS

Variable:	0 CITV DETECT RANGE	1 CITV DETECT RANGE	3 CITV DETECT RANGE
Sample size	2388	2379	3052
Average	2.1242	2.20585	2.13898
Median	2.109	2.294	2.2535
Mode	0.83	1.352	1.352
Geometric mean	1.91255	2.01682	1.86537
Variance	0.687722	0.659911	0.865863
Standard deviation	0.82929	0.812349	0.930518
Standard error	0.0169703	0.016655	0.0168435
Minimum	0.048	0.046	0.046
Maximum	4.461	5.264	4.525
Range	4.413	5.218	4.479
Lower quartile	1.5955	1.652	1.441
Upper quartile	2.6925	2.735	2.734
Interquartile range	1.097	1.083	1.293
Skewness	-0.0496248	-0.0451489	-0.0661504
Standardized skewness	-0.990011	-0.899019	-1.49193
Kurtosis	-0.352845	-0.314405	-0.65043
Standardized kurtosis	-3.51962	-3.13026	-7.33478

DAYLIGHT S.W. ASIA SCENARIOS

Variable:	0 CITV DETECT RANGE	1 CITV DETECT RANGE	3 CITV DETECT RANGE
Sample size	16749.	17881.	19698.
Average	4.480931	4.511059	4.55953
Median	4.52	4.519	4.589
Mode	3.403	4.196	4.646
Geometric mean	4.364821	4.41034	4.44323
Variance	0.941253	0.840367	0.958451
Standard deviation	0.970182	0.916715	0.979005
Standard error	0.007497	0.006855	0.006975
Minimum	1.002	1.006	0.393
Maximum	7.834	9.402	9.551
Range	6.832	8.396	9.158
Lower quartile	3.779	3.843	3.884
Upper quartile	5.327	5.282	5.383
Interquartile range	1.548	1.439	1.499
Skewness	-0.300801	-0.209779	-0.194196
Standardized skewness	-15.892696	-11.45204	-11.126921
Kurtosis	-0.624881	-0.533563	0.042434
Standardized kurtosis	-16.507676	-14.563847	1.215693
Coeff. of variation	21.651354	20.321515	21.471626

NIGHT S.W. ASIA SCENARIOS

Variable:	0 CITV DETECT RANGE	1 CITV DETECT RANGE	3 CITV DETECT RANGE
Sample size	16416.	16748.	18420.
Average	4.256046	4.347324	4.432285
Median	4.255	4.374	4.496
Mode	4.253	4.157	4.35
Geometric mean	4.126921	4.213905	4.296982
Variance	1.018239	1.05243	1.063516
Standard deviation	1.009078	1.02588	1.031269
Standard error	0.007876	0.007927	0.007598
Minimum	0.757	1.12	0.309
Maximum	7.813	8.183	12.956
Range	7.056	7.063	12.647
Lower quartile	3.514	3.624	3.707
Upper quartile	5.0545	5.1735	5.258
Interquartile range	1.5405	1.5495	1.551
Skewness	-0.118827	-0.185066	-0.181251
Standardized skewness	-6.215444	-9.777591	-10.042669
Kurtosis	-0.786408	-0.447471	0.530963
Standardized kurtosis	-20.567251	-11.820629	14.709698
Coeff. of variation	23.709285	23.597971	23.267207

APPENDIX E

COMPUTER PROGRAM

```
      PROGRAM KILLFIRE

********************************************************************
*              JOHN K. WOOD, Naval Postgraduate School, June 92    *
*                                                                  *
*     THIS PROGRAM READS THE TRAC-MTRY PM POST PROCESSOR CASUALTY *
*     REPORT OUTPUT FILE AND RENUMBERS LIKE-NUMBERED OPPOSING      *
*     WEAPON SYSTEMS. DATA COLUMNS FOR TIME, KILL TYPE, RANGE,     *
*     SIDE OF VICTIM, VICTIM SYSTEM TYPE, SIDE OF KILLER,          *
*     KILLER SYSTEM TYPE, AND KILLING MUNITION ARE WRITTEN TO AN   *
*     OUTPUT FILE.  THE USER MUST INPUT THE SOURCE FILE (A PM-     *
*     FORMATTED KILXXXXX.RPT), AND DESIGNATE AN OUTPUT FILE.       *
********************************************************************

      REAL  TIME, RANGE

      INTEGER  KILLCAT, SIDEVIC, VICTYPE, SIDEFIR, FIRTYPE, MUNTYPE
      INTEGER  SCN

      CHARACTER INFILE*12, OUTFILE*12

*******************************************************************
*     EXPLANATION OF VARIABLES:                                   *
*          TIME:  Time of casualty in fractions of minutes        *
*          RANGE: Range to victim in 1000s of meters;             *
*          MINE KILLS are shown with 0.0 range and kill code 9    *
*          KILLCAT:  JANUS(A) kill code                           *
*          SIDEVIC:  Side of the victim                           *
*          VICTYPE:  Weapon system type of victim                 *
*          SIDEFIR:  Side of firer/killer                         *
*          FIRTYPE:  Weapon system type of firer/killer           *
*          MUNTYPE:  Type of killing munition used                *
*          SCN:      Scenario number                              *
*******************************************************************

      PRINT *, 'INPUT THE NAME OF THE INPUT FILE'
      PRINT *, 'REMEMBER TO INCLUDE THE .RPT EXTENSION! IN QUOTES'
      READ *, INFILE
      PRINT *, 'YOU HAVE ENTERED THE FILE:  ', INFILE

      PRINT *, 'INPUT THE SCENARIO NUMBER. INTEGER ONLY! NO QUOTES!'
      PRINT *, 'EXAMPLE:  92 '
      READ *, SCN

      PRINT *, 'DESIGNATE A 12 CHARACTER  OUTPUT FILE NAME WITH QUOTES'
      PRINT *, 'EXAMPLE: DIRF1011.OUT'
      READ *, OUTFILE

      OPEN(UNIT=10, FILE = INFILE, MODE='READ')
      OPEN(UNIT=11, FILE = OUTFILE, MODE='WRITE')

      WRITE(11,*) 'SCN      TIME      KCAT      RANGE    SIDEV    VICT   SI

     &DEK  KILR   MUNTYP'
```

```
      PRINT *, 'PROCESSING THE CASUALTY FILE: ', INFILE, ' TO OUTPUT
     & FILENAME: ',OUTFILE

5     READ(10,10,END=40) TIME, KILLCAT, RANGE, SIDEVIC, VICTYPE,
     &  SIDEFIR, FIRTYPE, MUNTYPE

10    FORMAT(F10.5,1X,I3,1X,F7.3,1X,I1,4X,I3,24X,I1,4X,I3,21X,I3)

*******************************************************************
*                                                                 *
*   WE WANT TO CHANGE THE WEAPON SYSTEM CSD INDICATORS TO AVOID  *
*   CONFUSION FROM BOTH THE RED SYSTEM AND BLUE SYSTEM HAVING    *
*  THE SAME CSD SYSTEM NUMBER.  I HAVE SIMPLY ADDED 900 TO       *
*   RED SYSTEMS NUMBERS.                                         *
*                                                                 *
*                                                                 *
*******************************************************************

      IF (SIDEFIR .EQ.2) THEN
          IF((FIRTYPE .EQ. 55) .OR. (FIRTYPE .EQ. 51) .OR.
     &       (FIRTYPE .EQ. 3))THEN
                 FIRTYPE = FIRTYPE + 900
           ENDIF
      ELSEIF (SIDEVIC .EQ.2) THEN
          IF((VICTYPE .EQ. 55) .OR. (VICTYPE .EQ. 51) .OR.
     &       (VICTYPE .EQ. 3))THEN
                 VICTYPE = VICTYPE + 900
          ENDIF
      ENDIF

      IF (KILLCAT.EQ.9) RANGE = 0.0

25    WRITE(11,30)  SCN, TIME, KILLCAT, RANGE, SIDEVIC, VICTYPE,
     &  SIDEFIR, FIRTYPE, MUNTYPE

30    FORMAT(1X,I3,1X,F10.5,5X,I3,5X,F7.3,5X,I1,5X,I3,5X,I1,5X,I3,5X,I3)

      GO TO 5

40    CONTINUE

      CLOSE(UNIT=10)
      CLOSE(UNIT=11)

      STOP
      END
```

```
      PROGRAM DTECT

***********************************************************************
*             JOHN K. WOOD, Naval Postgraduate School, June 92   *
*                                                                    *
*     THIS PROGRAM READS THE TRAC-MTRY PM POST PROCESSOR DETECTION*
*     REPORT OUTPUT FILE AND RENUMBERS LIKE-NUMBERED OPPOSING       *
*     WEAPON SYSTEMS. DATA COLUMNS FOR TIME, SENSOR TYPE, RANGE,  *
*     SIDE OF SENSOR, SYSTEM TYPE, SIDE OF TARGET, AND TARGET TYPE*
*     ARE WRITTEN TO AN  OUTPUT FILE.   THE USER MUST INPUT THE    *
*     SOURCE FILE (A PM- FORMATTED DTCXXXXX.RPT),  AND DESIGNATE  *
*     AN OUTPUT FILE.                                                *
***********************************************************************

      REAL  TIME, RANGE

      INTEGER  SCN, SENSOR, SIDED, SIDET, DTCSYS, TGTSYS

      CHARACTER INFILE*12, OUTFILE*12
***********************************************************************
*     EXPLANATION OF VARIABLE NAMES:                                 *
*          TIME:  time of detection in fractions of minutes          *
*          RANGE:  range to target in 1000s of meters                *
*          SCN:  Designator for scenario number: e.g. 92             *
*          SENSOR:  Sensor designator:  See COMSYS.DAT file          *
*          SIDED:  Side of detector                                  *
*          SIDET:  Side of target                                    *
*          DTCSYS:  Weapon System Designator of detecting system    *
*          TGTSYS:  Weapon System Designator of Target system       *
***********************************************************************

      PRINT *, 'INPUT THE NAME OF THE INPUT FILE'
      PRINT *, 'REMEMBER TO INCLUDE THE .RPT EXTENSION! IN QUOTES'
      READ *, INFILE
      PRINT *, 'YOU HAVE ENTERED THE FILE:  ', INFILE

      PRINT *, 'INPUT THE SCENARIO NUMBER.  MUST BE INTEGER! NO QUOTES!'
      PRINT *, 'EXAMPLE:  92'
      READ *, SCN

      PRINT *, 'DESIGNATE A 12 CHARACTER  OUTPUT FILE NAME'
      PRINT *, 'EXAMPLE: DIRF1011.OUT'
      READ *, OUTFILE

      OPEN(UNIT=10, FILE = INFILE, MODE='READ')
      OPEN(UNIT=11, FILE = OUTFILE, MODE='WRITE')

      WRITE(11,*) ' SCN          TIME       SENSOR     RANGE     SIDED     D
     &TCSYS  SIDET  TGTSYS'

      WRITE(*,*) 'PROCESSING THE DETECTION FILE: ',INFILE, ' TO OUTPUT
     & FILENAME: ',OUTFILE

5     READ(10,10,END=40) TIME,  SENSOR, RANGE, SIDED, DTCSYS, SIDET,
     &                    TGTSYS

10    FORMAT(F10.5,1X,I3,1X,F7.3,1X,I1,4X,I3,24X,I1,4X,I3)
```

```
*******************************************************************
*                                                                 *
*     WE WANT TO CHANGE THE WEAPON SYSTEM CSD INDICATORS TO       *
*     AVOID CONFUSION FROM BOTH THE RED SYSTEM AND BLUE SYSTEM    *
*     HAVING THE SAME CSD SYSTEM NUMBER.  I HAVE SIMPLY ADDED     *
*     900 TO THE RED SYSTEM NUMBERS.                              *
*                                                                 *
*******************************************************************

      IF (SIDED .EQ.2) THEN
          IF((DTCSYS .EQ. 55) .OR. (DTCSYS .EQ. 51) .OR.
     &       (DTCSYS .EQ. 3))THEN
              DTCSYS = DTCSYS + 900
           ENDIF
      ELSEIF (SIDET .EQ.2) THEN
          IF((TGTSYS .EQ. 55) .OR. (TGTSYS .EQ. 51) .OR.
     &       (TGTSYS .EQ. 3))THEN
              TGTSYS = TGTSYS + 900
          ENDIF
      ENDIF

      IF((SIDED.EQ.1).AND.((DTCSYS.EQ.51).OR.(DTCSYS.EQ.52).OR.
     &   (DTCSYS.EQ.69)))THEN

25            WRITE(11,30)  SCN, TIME, SENSOR, RANGE, SIDED, DTCSYS,
     &                      SIDET, TGTSYS

30            FORMAT(1X,I5,3X,F10.5,6X,I3,6X,F7.3,6X,I1,6X,I3,6X,I1,6X,
     & I3)
      ENDIF

      GO TO 5

40    CONTINUE

      CLOSE(UNIT=10)
      CLOSE(UNIT=11)

      STOP
      END
```

```
      PROGRAM DIRFIRE

************************************************************************
*             JOHN K. WOOD, Naval Postgraduate School, June 92   *
*                                                                 *
*     THIS PROGRAM READS THE TRAC-MTRY PM POST PROCESSOR DIRECT   *
*     FIRE REPORT OUTPUT FILE AND RENUMBERS LIKE-NUMBERED OPPOSING*
*     WEAPON SYSTEMS.  DATA COLUMNS FOR TIME, RANGE, SIDE, FIRER  *
*     SYSTEM TYPE SPEED OF FIRER, TYPE WEAPON, SIDE OF VICTIM,    *
*     VICTIM SYSTEM TYPE, AND SPEED OF VICTIM ARE WRITTEN TO AN   *
*     OUTPUT FILE.   THE USER MUST INPUT THE SOURCE FILE (A PM-   *
*     FORMATTED DFRXXXXX.RPT),  AND DESIGNATE AN OUTPUT FILE.     *
************************************************************************

      REAL  TIME, RANGE, SPEEDF, SPEEDV

      INTEGER  SIDEFIR, FIRTYPE, WPNTYPE, SIDEVIC, VICTYPE, SCN

      CHARACTER INFILE*12, OUTFILE*12

************************************************************************
*     EXPLANATION OF VARIABLE NAMES:                              *
*          TIME:  time of engagement in fraction of minutes       *
*          RANGE: range of engagement in 1000s of meters          *
*          SIDEFIR:  side of the firing system                    *
*          FIRTYPE:  Weapon system designator of firing system    *
*          WPNTYPE:  Weapon of Weapon system used for engagement *
*          SIDEVIC:  Side of victim                               *
*          VICTYPE:  Weapon system designator of victim           *
*          SCN:      Scenario designator                          *
*     For an explanation of Weapon System Codes see the JANUS(A) *
*     COMSYS.DAT  file.                                           *
************************************************************************

      PRINT *, 'INPUT THE NAME OF THE INPUT FILE'
      PRINT *, 'REMEMBER TO INCLUDE THE .RPT EXTENSION! IN QUOTES'
      READ *, INFILE

      PRINT *, 'YOU HAVE ENTERED THE FILE:   ', INFILE
      PRINT *, 'INPUT THE SCENARIO NUMBER. MUST BE INTEGER! NO QUOTES!'
      PRINT *, 'EXAMPLE:  92'
      READ *, SCN

      PRINT *, 'DESIGNATE A 12 CHARACTER  OUTPUT FILE NAME'
      PRINT *, 'EXAMPLE: DIRF1011.OUT'
      READ *, OUTFILE

      OPEN(UNIT=10, FILE = INFILE, MODE='READ')
      OPEN(UNIT=11, FILE = OUTFILE, MODE='WRITE')

      WRITE(11,*) ' SCN      TIME    RANGE  SIDEF  F-TYPE  SPDF   WPN  S
     &IDEV  VICT    SPDV'


      PRINT *, 'PROCESSING THE ENGAGEMENT FILE: ',INFILE,' TO OUTPUT
     & FILENAME: ', OUTFILE

5     READ(10,10,END=40) TIME, RANGE, SIDEFIR, FIRTYPE, SPEEDF, WPNTYPE,
     &  SIDEVIC, VICTYPE, SPEEDV
```

```
10    FORMAT(F10.5,3X,F5.3,1X,I1,4X,I3,22X,F5.2,5X,I2,10X,I1,8X,I3,
     &      22X,F5.2)

******************************************************************
*                                                                *
*     WE WANT TO CHANGE THE WEAPON SYSTEM CSD INDICATORS TO AVOID *
*     CONFUSION FROM BOTH THE RED SYSTEM AND BLUE SYSTEM HAVING  *
*     THE SAME CSD SYSTEM NUMBER.  I HAVE SIMPLY ADDED 900 TO    *
*     THE RED SYSTEM NUMBERS.                                    *
*                                                                *
******************************************************************

      IF (SIDEFIR .EQ.2) THEN
          IF((FIRTYPE .EQ. 55) .OR. (FIRTYPE .EQ. 51) .OR.
     &       (FIRTYPE .EQ. 3))THEN
               FIRTYPE = FIRTYPE + 900
          ENDIF
      ELSEIF (SIDEVIC .EQ.2) THEN
          IF((VICTYPE .EQ. 55) .OR. (VICTYPE .EQ. 51) .OR.
     &       (VICTYPE .EQ. 3))THEN
               VICTYPE = VICTYPE + 900
          ENDIF
      ENDIF

      IF((SIDEFIR.EQ.1).AND.((FIRTYPE.EQ.51).OR.(FIRTYPE.EQ.52).OR.
     &   (FIRTYPE.EQ.69)))THEN

25         WRITE(11,30) SCN, TIME, RANGE, SIDEFIR, FIRTYPE, SPEEDF,
     &          WPNTYPE, SIDEVIC, VICTYPE, SPEEDV

30         FORMAT(2X,I3,2X,F9.5,3X,F5.3,4X,I1,4X,I3,4X,F5.2,4X,I2,4X,
     &          I1,4X,I3,4X,F5.2)

      ENDIF

      GO TO 5

40    CONTINUE

      CLOSE(UNIT=10)
      CLOSE(UNIT=11)

      STOP
      END
```

LIST OF REFERENCES

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